

# Managing Stormwater Sediment Best Management Practice Guidance for Municipalities



Minnesota Pollution Control Agency

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# Stormwater Sediment Best Management Practices

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These stormwater sediment best management practices (BMPs) provide guidance for the removal of sediment from stormwater collection and conveyance systems. This guidance document will help you think through important steps associated with sediment removal projects. These may include:

- Who is responsible for managing stormwater sediment
- Land use within a drainage area
- Sampling sediment and what laboratory analysis is required
- How to calculate benzo[a]pyrene (B[a]P) equivalents for carcinogenic polycyclic aromatic hydrocarbons (cPAHs)
- Management requirements for contaminated sediment
- Where contaminated stormwater sediments are accepted for disposal
- Who to contact if you have questions

This document is intended to help those responsible for operation and maintenance of stormwater systems determine when sediment removal is needed, and what steps to consider during the course of managing a sediment removal project. This is guidance. It is not a comprehensive list of everything you may need to do when managing a sediment removal project. Other considerations may also include:

- Geographic or environmental sensitivities
- Landscape variations, and soil types
- Management of native or invasive species
- A wide range of variables that may be encountered from one municipality to the next, or one project to the next

This guidance was developed to give local units of government, and others responsible for managing stormwater collection and conveyance systems, a big picture understanding about how to manage sediment removal projects and what you may need to consider before, during, and after a project.

This guidance was developed with special assistance from the cities of Burnsville, Circle Pines, Maplewood, Roseville, St. Paul, White Bear Lake, and Woodbury, Minnesota.

## Background

Action was taken during the 2009 Minnesota legislative session which included funding to conduct research on stormwater pond sediment contamination and to help Minnesota cities clean-out stormwater contaminated ponds. (*House File Number 1231 Passed by the Minnesota Legislature on May 18, 2009 and Approved by Governor Tim Pawlenty on May 22, 2009.*)

Research concluded that polycyclic hydrocarbons (PAHs) are often responsible for the greatest contamination problems in stormwater pond sediment. PAHs 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 (Crane et al. 2010). Coal tar-based sealants are a major source of PAHs in urban sediments (Mahler et al. 2012). The Minnesota Pollution Control Agency's (MPCA) research determined that coal tar-based sealants were the most important source of PAHs (58.2 percent), followed by oil-based PAHs (15.0 percent) and vehicle emission sources (14.7 percent).

The legislation also provided funding for municipalities who agree to pass ordinances banning or restricting the use of coal tar-based sealants; as of June 2012, 20 municipalities have passed such ordinances (<http://www.pca.state.mn.us/index.php/view-document.html?gid=16180>).

The 2009 legislation also directed the MPCA to develop BMPs to avoid or mitigate impacts of PAH contamination from coal tar-based sealants. The MPCA provides guidance for the operation and maintenance of stormwater conveyance and collection systems. Stormwater collection and conveyance systems are commonly referred to as stormwater ponds, stormwater control devices, wet detention basins, or National Urban Runoff Program (NURP) ponds.

This document provides guidance for sediment removal projects from stormwater ponds of any sort. Sediment may also be generated in other stormwater devices such as sumps, traps, pipes, or other conveyance structures. This guidance may be adapted for other situations to determine representative concentrations of contaminants of potential concern. The analytical component outlined in Appendix A may be applied to other sediment sampling situations, but the MPCA does not have specific sampling guidance at this time for those situations and it is not necessary to follow this guidance for other types of sediment removal projects. The sampling guidance provided in Appendix A is strictly for sampling sediment from stormwater ponds.

These BMPs will continue to be updated to include new information and data about stormwater sediment and will be incorporated as a chapter in the MPCA Stormwater Manual once updates to the manual are completed. The MPCA Stormwater Manual can be found on the MPCA website at:

<http://www.pca.state.mn.us/index.php/view-document.html?gid=8937>.

## Sediment removal cost

The high cost to manage contaminated stormwater sediment has brought operation and maintenance of stormwater ponds into the public spotlight. Unregulated sediment can be managed locally and without disposal restrictions that make them far less costly to manage. Disposal costs for a stormwater sediment removal project can be as much as three times more expensive depending on the type and level of contamination in the sediment. This emphasizes the value and importance of source control to reduce the loading of contamination into stormwater ponds.

Stormwater collection systems concentrate pollutants by design. These systems include:

- Wetlands converted for the specific purpose of conveying, treating, or otherwise managing stormwater
- Ponds, or small lakes which have been designated for the specific purpose of conveying, treating, or otherwise managing stormwater
- Structures engineered, built, constructed, and/or man-made devices for the specific purpose of conveying, treating, or otherwise managing stormwater.

Stormwater collection systems are intended to help protect infrastructure from flooding and to collect and concentrate pollutants to prevent them from reaching lakes, rivers, streams, wetlands, and other waters of the state where they could have a negative effect on water quality, aquatic animals, or human health. Managing contamination and pollutants in the sediment of stormwater collection systems should be expected. "Sampling is conducted to guide proper management of contaminated sediment".

# Stormwater sediment removal process

1. Inventory and maintenance needs
2. Evaluating and testing sediment
3. Engineering, contracting, and work plans
4. Excavating sediment
5. Site restoration
6. Records and documentation to keep on file.

## 1. Inventory and maintenance needs

Assessing need and planning sediment removal projects includes a number of steps that range from estimating lost capacity to notifying neighbors about plans to maintain the stormwater collection system. For municipalities who are managing dozens, or sometimes hundreds of stormwater ponds, starting with an inventory and a maintenance prioritization process is recommended.

Some municipalities find it helpful to develop a flowchart or other prioritization scheme to triage and track priority sediment removal projects. Topics of importance may include:

- Priorities identified by city inspections – sediment level, lost capacity, other needs.
- Natural wetland verses constructed ponds. Constructed ponds come first.
- Accessibility. Does the city already have access via parkland, easement, or outlot?
- What are the sediment analysis results? Can the city afford to remove and manage the sediment?
- Is the downstream lake or sub-watershed a priority?
- What is the expected cost/benefit from the project?
- Can a stormwater pond be expanded to provide greater benefit?
- Is surveying needed to assess lost capacity and depth of excavation?
- How will you measure or estimate the volume of cubic yards of sediment to be removed?
- Have sediment deltas and inlet/outlet structures been identified/located?
- Where are your access points for machinery?
- Are communications with other stakeholders important/public relations?
- Are visual inspections, notes, checklists, or photos to track maintenance projects needed?

The first phase of work identifies need and determines if a sediment removal project is even necessary. This may include a preliminary survey to gage sediment depth and provide a rough estimate of the number of cubic yards of sediment to be removed. This assessment and planning will help guide work plan development and contracting if a sediment removal project is deemed necessary.

## 2. Evaluating and testing sediment

Collecting sediment samples and testing sediment helps characterize what contaminants are present. This step helps identify contaminants of potential concern and what management options are available. Sampling results limit where sediment can go and this affects work plan development including contract specifications for bidding projects. This is a very important part of the management process. This guidance is summarized in the following appendices:

- Guidance for *collecting samples and testing sediment* are outlined in Appendix A.
- Guidance for calculating *B[a]P equivalents and comparing chemical concentrations to Soil Reference Values* are summarized in Appendix B.

Knowledge about land use categories in the watershed will help with subsequent steps in this process. In urban areas, the following land uses are of greatest interest for stormwater collection systems:

- Residential
- Commercial
- Industrial

**Residential land uses** range from low density (houses are on lots of more than an acre) to high density (multiple-unit structures such as apartments and condominiums). Residential areas generally have a uniform size and spacing of structures, linear driveways, and lawn areas. Most churches and small schools are included in this category, too (Anderson et al. 2001).

**Commercial land uses** include areas where products are sold and services are provided. These land uses include urban central business districts, shopping centers, commercial strip developments, junkyards, and resorts. Institutional land uses such as larger educational, religious, health, correctional, and military facilities are included in this category, too. Office buildings, warehouses, driveways, sheds, parking lots, landscaped areas, and waste disposal areas supporting the basic uses are included in commercial land uses (Anderson et al. 2001).

**Industrial land uses** range from light manufacturing to heavy manufacturing plants. Light industries design, assemble, finish, process, and package products, while heavy industries use raw materials such as iron ore, timber, or coal (e.g., steel mills, pulp and lumber mills, electric power generating stations, oil refineries and tank farms, contaminant plants, and brick making plants). Industrial land uses may include buildings, parking lots, loading docks, access roads, processing facilities, stockpiles, storage sheds, and numerous vehicles (Anderson et al. 2001).

It is the responsibility of the owner or responsible party to evaluate the drainage area of each stormwater collection system to determine whether spills, improper disposal, or the potential for a release from commercial or industrial operations indicate that sampling for other contaminants are needed. For example, if sediment is being removed from a pond in an industrial park and there has been a release of contaminants known to accumulate in sediments (like nickel and silver from a metal plating facility), then the owner or responsible party should include those contaminants on the list for sampling.

Laboratory analysis is required to determine management or treatment options. Guidance for collecting samples and testing sediment are described in Appendix A.

Management options include:

1. **Unregulated fill.** Laboratory analysis determines that contaminants of potential concern are below levels that require special management. Excavated sediment can be managed in accordance with the MPCA's BMP for the Off-Site Use of Unregulated Fill.  
<http://www.pca.state.mn.us/index.php/view-document.html?gid=13503>.
2. **Regulated solid waste.** Laboratory analysis determines that contaminants of potential concern in the stormwater sediment require special management and cannot be used as clean fill.

Contaminated sediment is currently guided to a landfill if it cannot be used as a clean fill. Depending on the types and concentrations of contaminants; sediment may need to be disposed of at a Municipal Solid Waste (MSW) landfill that has an industrial solid waste management plan. This means contaminated sediment must go to a MSW landfill that has a liner and a leachate collection system.

MSW landfills in Minnesota that can accept these types of waste can be found on this webpage:

<http://www.pca.state.mn.us/veiz806> or, the list can be accessed directly at this link:

<http://www.pca.state.mn.us/index.php/view-document.html?gid=12806>.

Some additional landfills that are permitted to accept industrial waste, and which may also accept contaminated stormwater sediments, include:

1. Voyageur Industrial Landfill in Cannon Falls, Minnesota
2. Vonco II Landfill in Becker, Minnesota
3. Vonco V Landfill in Duluth, Minnesota
4. Shamrock Environmental Landfill in Cloquet, Minnesota
5. Dem-Con Landfill in Shakopee, Minnesota
6. Veolia E S Rolling Hills Landfill in Buffalo, Minnesota
7. SKB Rosemount Industrial Waste Facility in Rosemount, Minnesota

It is recommended that you contact the facility to ensure they will be able to accept your waste and to determine what sampling requirements are required by the facility.

### **3. Engineering, contracting, and work plans**

Work plan development includes a wide range of logistics including, but not limited to:

- Notification of residents and neighbors.
- How to access the site and what machinery will be needed to remove sediment.
- Define how sediment will be removed, measured, and paid for.
- Testing or analysis requirements for the destination disposal or treatment facility.
- Plans for erosion control.
- Tree removal, environmental impact, depth to ground water, and risks associated with the displacement of wildlife or invasive species.
- Lack of design and/or construction documentation (no “as-built” records).
- Estimating water draw-down needs and the amount of time and oversight needed to drain the stormwater collection system.
- What permits (if any) may be required by your local watershed district, county, or the Department of Natural Resources. The MPCA does not require a permit or notification for routine maintenance of stormwater ponds, but cities are advised to keep records and documentation of their sediment removal projects as outlined in this guidance.
- Defining appropriate BMPs for dewatering (e.g., rock riprap, sand bags, plastic sheeting, or other accepted energy dissipation measures), such that the discharge does not adversely affect the receiving water or downstream landowners.
- Ensuring that water from pumping or draw-down activities is discharged in a manner that does not cause nuisance conditions, erosion in receiving channels, or erosion on down-slope properties. This also includes inundation of wetlands causing significant and/or adverse impact. The general rule of thumb is “keep it clear”.
- How sediment will be transported and a process to track the volume of sediment removed.
- Defining logistics, administrative, and engineering requirements, surveys, dewatering processes, site access and easements, rock entrance and off-site tracking needs, coordination with adjacent cities, and/or watershed districts and the Minnesota Department of Transportation.



## 4. Excavating sediment

Sediment excavation projects are recommended to take place during the winter. Benefits include:

- Winter excavations greatly reduce the risk that rain may cause flooding and erosion of dewatered ponds, or turbid runoff conditions.
- Access with trucks and heavy machinery is easier in the winter when soil surrounding stormwater ponds freezes solid.
- Adjacent residents and neighbors have windows closed and this means less noise, less dust, less odor, and fewer disturbances overall.
- Water can be pumped down so remaining water can freeze solid. Pumping should be discontinued before the bottom of the pond is disturbed and sediment is stirred up making the water turbid. Remaining water should be allowed to freeze solid trapping any suspended sediment in ice. The ice can then be skimmed off with a bulldozer so it can be piled within the pond. This keeps turbid water in the basin after snow and ice melt during spring thaw.

Winter excavation projects also have a few drawbacks. They include:

- Shorter working days
- Problems associated with working in freezing conditions and sub-zero weather
- The use of lights after dark to extend the work day

Sediment removal can begin once snow and ice have been skimmed off and piled within the pond.

A more precise survey is usually conducted at this time to better estimate the amount of sediment to be removed and to identify the depths of excavation to achieve a final grade that restores desired capacity.

If the removal volume is not defined by survey, then establishing a standard volume per truck and counting the number of trucks leaving the site can be used to track the volume in cubic yards.

Once sediment is removed, final grading should achieve a natural (gradual) slope for all banks. Ice and snow that has been stockpiled in the pond should be evenly distributed throughout the basin once sediment has been removed. This will allow water and remaining sediment to be retained in the pond. Temporary stabilization of slopes and banks should ensure control of erosion and prevent site run-off during spring snowmelt and the first rain events of the season. Clean-up and removal of temporary infrastructure should be done working your way out of the site. Once you remove equipment and temporary infrastructure (such as transport roads and rock entrances), it will be cost prohibitive and essentially impossible to make additional corrections.

## 5. Site restoration

Site restoration work should be conducted as soon as weather conditions permit and may include:

- Additional clean-up or maintenance of inlet and outlet structures
- Additional site stabilization work including sediment and erosion control
- Establishing plants, seed, sod, mulch, or vegetation to prevent erosion (above water line)
- Professional engineer sign-off on project completion.

## 6. Records and documentation to keep on file

It is important to keep good records about the operation and maintenance of stormwater collection systems. Good records will not only assist with an accurate inventory and triage of stormwater ponds, but they can also provide the basis for sound planning in the future. Important records and documentation for sediment removal projects may include:

- Date of excavation
- Amount removed
- Laboratory results
- Place of disposition
- "As Built" prints or plans if they exist
- Contractor information, shipping papers/manifests/contractual agreements
- Any other observations about the removal that will help the city operate and maintain that site in the future.

For more information on PAH-contaminated stormwater sediment, or information about stormwater best management practices, contact Don Berger at 651-757-2223 or e-mail to: [donald.berger@state.mn.us](mailto:donald.berger@state.mn.us).

## References

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## Appendix A: Sediment Sampling and Analytical Technical Guidance

This technical guidance should be shared with the staff or environmental consultants responsible for sampling sediments and interpreting the analytical results for the owner or responsible party. It is the responsibility of the owner or responsible party to either train their staff or select consultants who can perform these tasks.

### What's New?

- The number of sediment samples to be collected now depends on the surface area of the stormwater pond instead of the volume of material to be excavated from the pond.
- For the analysis of polycyclic aromatic hydrocarbons (PAHs) from sediment samples, analytical laboratories must use clean-up columns (instead of only diluting the sample extract) to remove interferences from the sample extract. This will result in lower reporting limits and better data for making management decisions.
- The MPCA has reduced the number of carcinogenic PAHs (cPAHs) to be measured in sediment samples from 25 to 17 compounds.

### Sediment sampling

The U.S. Environmental Protection Agency's report on "Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual" (USEPA 2001) provides guidance on sediment monitoring plans, collection of whole sediments, field sample processing, transport and storage of sediments, sediment manipulations, and quality assurance/quality control (QA/QC) issues. This report should be used as a resource by owners or responsible parties, and their consultants, for sampling and processing stormwater pond sediments. In particular, this user-friendly document provides pictures of sediment sampling equipment, flowcharts for making decisions, check lists, and boxes of important bulleted items.

#### *Sediment characterization*

Stormwater pond sediments are very complex, and chemical results can vary greatly within a few yards of each sample. This feature makes it more difficult to provide generic guidance for a broad suite of stormwater ponds. The ponds themselves may differ based on whether the pond originated as a natural feature or was constructed for the purpose of stormwater management. These ponds also vary in size and shape, and some ponds may have multiple inlets and outlets. Finally, the type of land uses in the drainage areas of the ponds can influence contaminant concentrations in the pond sediments. Based on the MPCA's 2009 stormwater pond study (Crane in review), coal tar-based sealant sources comprised 58 percent of total PAHs (based on a suite of 34 PAHs) in surface sediments of ponds located primarily in residential, commercial, and industrial land use areas. Watersheds where coal tar-based sealants are used on driveways and parking lots will have higher concentrations of PAHs in nearby stormwater pond sediments than those that use either asphalt-based sealants (which have much lower concentrations of PAHs), no sealant, or use other material such as concrete, permeable pavers, or gravel for driveways and parking lots.

The MPCA is requiring owners or responsible parties to sample sediments prior to dredging to determine concentrations of 17 cPAHs, noncarcinogenic PAHs, arsenic, and copper. Analysis of sediment samples for particle size and total organic carbon (TOC) is optional, but this information may be useful for some beneficial reuse scenarios of the dredged material. If the owner or responsible party is aware of other known or suspected sources of contamination, they should collect sufficient volumes of sediment samples to have other parameters evaluated. The analytical laboratory will provide guidance on how much sediment is needed for each analysis. Since it can sometimes take several months from the time field sampling is conducted to when the analytical results become available for assessing management options, the field sampling needs to be conducted early on in the process after conducting an inventory of stormwater ponds and determining maintenance needs.

If the annual volume of sediment to be removed is less than 100 cubic yards, such as from a sump or forebay area near a pond inlet or outfall, then no chemical testing or other sediment characterization is required. The owner or responsible party is responsible for the due diligence in the reuse and/or disposal of this material. When more than 100 cubic yards of sediment need to be removed, some important general guidance for characterizing sediment is as follows:

- Sampling should be to the planned depth of excavation or greater. The MPCA has provided previous guidance to collect sediment samples in two foot intervals (e.g., 0 – 2 ft, 2 - 4 ft), but it is up to the owner or responsible party to collect sediment samples that will cover the depth to be dredged. If it is easier in the field to collect two foot depth intervals, then by all means continue to do this. The important issue is to send a sediment sample to the analytical laboratory that is representative of the entire depth interval to be excavated. Since collecting sediment from two or more long (2 ft) cores may entail a large mass of sediment, it may be easier to slice the core from top to bottom and only analyze half of the slice; this slice can be combined with a deeper layer slice to provide one composite sample for the analytical laboratory to analyze. It is not acceptable to randomly scoop out bits of sediment from different portions of the sediment core to composite together since doing so may miss out on the historical record of sediments (and contaminants) deposited in different depth intervals.
- Core samplers are more appropriate to use to obtain cohesive sediment samples at depth than grab samplers. Grab samplers can be used to collect surface samples if the sediment samples are too floccy (loose) with vegetative detritus (e.g., parts of cattail stalks/leaves) or are too sandy to be retained in a core sampler.
- Geopositional coordinates need to be collected at the location of each sample site.
- The number of samples to be collected depends on the surface area of the pond. **[Note: this is a change in policy from previous MPCA guidance (Stollenwerk *et al.* 2011) that recommended the number of samples per the estimated volume of dredge material.]** The goal is to collect sediment samples that are representative of the material that will be removed to maintain the functionality of the stormwater pond.
  - Multiple samples need to be collected, particularly since some compounds may be not be detected in all areas of the pond.
  - For stormwater ponds with a surface area less than or equal to one acre, at least two stations need to be sampled for chemical analysis. Sample sites may either be selected randomly or by a transect from the main inlet to the outlet of the pond.
  - For ponds greater than one acre and less than four acres, one sampling station should be located in each acre and portion of an acre of the pond. In some cases, multiple samples may need to be collected at the same station and composited together to provide an adequate mass of sediment for the analytical work. Sample sites may either be selected randomly or in a transect from the main inlet to outlet of the pond.

- For ponds larger than four acres, divide the pond into four sections (quadrants) as shown in Figure A-1. Select at least five sites (i.e., subsamples) within each quadrant using either the dice pattern shown in Figure A-1 or using a random sampling strategy. Sediment from each subsample needs to be homogenized (mixed well) in a precleaned container (large 4 L Pyrex mixing cups work well; larger volumes can use precleaned buckets). An equal aliquot of sediment from each subsample is then composited together to form the sediment sample for that quadrant that is submitted to the analytical laboratory.
- For natural ponds larger than 4 acres that have an irregular shape, such as bays off the main pond, each bay should be sampled if it is targeted for dredging. Depending on the size of the bay, use the aforementioned guidance for developing a sampling plan.
- If more than 10 samples are collected for analysis (possibly from a study of multiple ponds during the same time period), a field replicate sample needs to be collected for every 10 samples (i.e., 10% of samples). A field replicate is collected in close proximity to the other sample and provides a measure of field precision.
- Remove any rocks, pebbles, trash, large invertebrates (like beetles), or large pieces of detritus from each subsample and composite sample.
- Overlying water needs to be decanted from the subsamples and composite sediment sample in the field prior to splitting the sample into the sample jars.
- Sediment samples need to be homogenized (mixed well) before splitting the sample into precleaned jars for the PAH and metals analyses. Most analytical laboratories will provide precleaned jars and sample labels for their clients. It is important with PAHs to use amber, pesticide-grade, precleaned glass jars with Teflon™-lined lids since PAHs may be degraded by sunlight. Use a permanent marker to fill out the sample label; it is helpful to wrap clear packing tape around the label to secure it on the jar since sometimes the labels can come loose while the sample jars are stored on ice during field sampling.
- Store the sediment samples on ice (or ice packs) in a cooler during field sampling. Next, either transfer the samples directly to the analytical laboratory or store them in an interim refrigerator or freezer prior to submitting to the laboratory. If the sediment samples are to be frozen, make sure the sample jars are not filled more than two-thirds full to allow room for expansion while the sediment freezes.

#### *Submit samples to analytical laboratories*

The following steps need to be completed before the sediment samples are ready to submit to the analytical laboratory:

- After the sediment has settled in the sample jars in the refrigerator, additional overlying water should be carefully removed prior to submitting the samples to analytical laboratories. Use of a pre-cleaned, wide-bore pipette to remove overlying water is better than decanting the sample since it will not disturb the sediment as much in the jar. If the laboratory receives sediment samples that have a high water content, then there may not be enough mass of sediment available to do their analyses. If the sediments are “soupy” or have a lot of plant detritus (such as from cattails), then it would be a good idea to submit extra sediment to the laboratory.
- Provide the analytical laboratory with recommendations on which sample(s) would make good candidate Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples for the cPAH analysis. This is important since the laboratory receives a subset of the sample collected and does not have the field sampling observations the field sampling crew had with collecting the larger sample. If guidance is not provided and the laboratory ends up selecting a sediment sample high in PAHs (as occurred with the MPCA’s stormwater pond study), the results of the MS/MSD will not be useable and the client will still be charged for this analysis. Good candidate samples would

be expected to have lower concentrations of PAHs so that the spike level will be at least five times greater than the background sample. Avoid designating samples that have strong petroleum odors, have an oil sheen overlying the sediment, or are dark black and oily in appearance since these samples are likely to have high concentrations of PAHs.

- Sample tracking forms or chain-of-custody forms are helpful to use during field sampling to record observations about the sediment samples and to provide field sampling information (e.g., sample station, date, time, sampling equipment, analyses to be done). Most analytical laboratories will provide their clients with a chain-of-custody form; provide a copy to the analytical laboratory when the samples are submitted or shipped to them.

#### **How to Select an Analytical Laboratory:**

1. If the municipality is a Cooperative Purchasing Venture (CPV) member, they can access the State of Minnesota's Sampling and Laboratory Services contract to obtain State-negotiated contract prices. If needed, assistance in accessing the contract is available from Martina Cameron (MPCA) at: [martina.cameron@state.mn.us](mailto:martina.cameron@state.mn.us) or 651-757-2259. If assistance is needed to find a contract laboratory capable of performing cPAH analyses, then contact Bill Scruton (MPCA) at: [bill.scruton@state.mn.us](mailto:bill.scruton@state.mn.us) or 651-757-2710.
2. If the municipality is not currently a CPV member but would like to become one, sign-up for this program from the Minnesota Department of Administration's website at: <http://www.mmd.admin.state.mn.us/cpvfags.htm#M>. There is no charge to sign-up, and it is open to all municipalities.
3. If the municipality wants to find a commercial laboratory for cPAHs without using the State contract, go to the following link for the Minnesota Department of Health's Certification website to find a laboratory certified for this analysis in Minnesota: <https://apps.health.state.mn.us/elddo/public/accruitedlabs/labsearch.seam>. From this website, click on the "customized searches" tab. At the Program drop down arrow, click on "Resource Conservation Recovery Program." Next, click "search" at the bottom of the page. Click "view" on the right-hand side of the page in line with the laboratory contact information to scroll down the list of laboratory capabilities. Look for RCRA method 8270D SIM. The Minnesota Department of Health does not actually certify laboratories for either the cPAH method or the extra PAHs beyond the U.S. Environmental Protection Agency (EPA) list of 16 priority pollutant PAHs. The municipality should ask the laboratory if they do the cPAH list, also known as the Minnesota Extended List of PAHs.

### **Analytical considerations**

This guidance may be updated in the future as new screening and analytical methods become available.

#### *Preparation*

Laboratories that freeze dry the sediment samples prior to extraction and analysis for PAHs and metals, as well as other contaminants of potential concern, reduce or eliminate the problems of wet samples. These laboratories are also able to achieve lower detection limits and more quantitative determinations. Freeze drying of the sample also allows for complete homogenization of the sample matrix, which will result in improved precision. Although not a requirement, better results may be obtained using this preparation method.

## *Analytical methods*

The primary analytical methods are provided below:

- The extended list of PAHs, including 17 cPAHs (Table A-1) and noncarcinogenic PAHs, must be analyzed based on EPA Method 8270 by gas chromatography/mass spectrometry (GC/MS) with selective ion monitoring (SIM) as optional.
  - Since sediments from stormwater ponds usually contain interfering compounds, it is required that the analytical laboratory run the sample extracts through clean-up columns, rather than just diluting the sample extract to reduce interfering compounds. An example clean-up process is to pass the sample extract through an alumina (and/or silica gel) column to isolate the hydrocarbon fraction. A layer of activated copper can be added to the bottom of the column or to the sample extract to remove any sulfur that may have been present in the samples. Note that 14 cPAHs were detected in the MPCA's study of stormwater pond sediments (Crane in review), and either more cPAHs or a greater percentage of cPAHs may have been detected if the local laboratory had used clean-up columns instead of diluting the sample extracts (Table A-2). These results, in addition to other factors described in Table A-2, were used to shorten the list of cPAHs from 25 to 17 compounds.
  - The analytical laboratory must be asked to note J-flagged data that are in-between the method detection limit and the reporting limit.
- Metals should be analyzed by inductively coupled plasma—mass spectrometry (ICP—MS) using reference method SW 6020. Occasionally, confirmation of the metal may be needed using graphite furnace atomic absorption spectrophotometry.
- Percent moisture should be determined using reference method ASTM D2216.
- Total organic carbon (TOC), if needed, can be analyzed using EPA method 9060a.
- Particle size, if needed, can be analyzed multiple ways to determine percent sand, silt, and clay.

## *QA/QC data quality indicators*

The field sampling procedures and analytical methods include several QA/QC measures to ensure useable data are collected and measured. In particular, data quality indicators (DQIs) are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of data. The principal DQIs are precision, bias, representativeness, comparability, and completeness; these terms are described further in Attachment 1. Establishing acceptance criteria for the DQIs sets quantitative goals for the quality of data generated in the analytical measurement process.

- For cPAHs and noncarcinogenic PAHs by EPA Method 8270, the DQIs are:
  - Blanks: <5 times the method detection limit (MDL); procedural blanks should be prepared with each analytical batch.
  - Surrogate Recovery: 40-120% the recovery of the surrogate compounds are used to measure data quality in terms of accuracy (extraction efficiency).
  - Laboratory Control Sample (LCS) and Matrix Spike (MS) Recovery: 40-120%; the percent recoveries of target analytes are calculated to measure data quality in terms of accuracy
  - MS/Matrix Spike Duplicate (MSD) Precision: relative percent difference (RPD) <30%; this is used to evaluate the data in terms of precision.
  - Reporting Limit of 10-30 µg/kg dry weight for individual PAH compounds.

- For metals (arsenic and copper):
  - Blanks: <5 times the MDL; procedural blanks should be prepared with each analytical batch.
  - Precision (% RPD): <10%
  - Accuracy: 85 – 115%
  - Reporting Limit: 0.10 mg/kg dry wt.

#### *Electronic data requirements*

- Electronic copies of the data should be obtained from the analytical laboratory in spreadsheet format (e.g., Microsoft Excel).
- In the future, the MPCA may be interested in obtaining electronic copies of the analytical results for archiving it in the MPCA's database system. At the present time, though, the MPCA's database platform, EQulS, is not set-up to accommodate sediment chemistry data

## References

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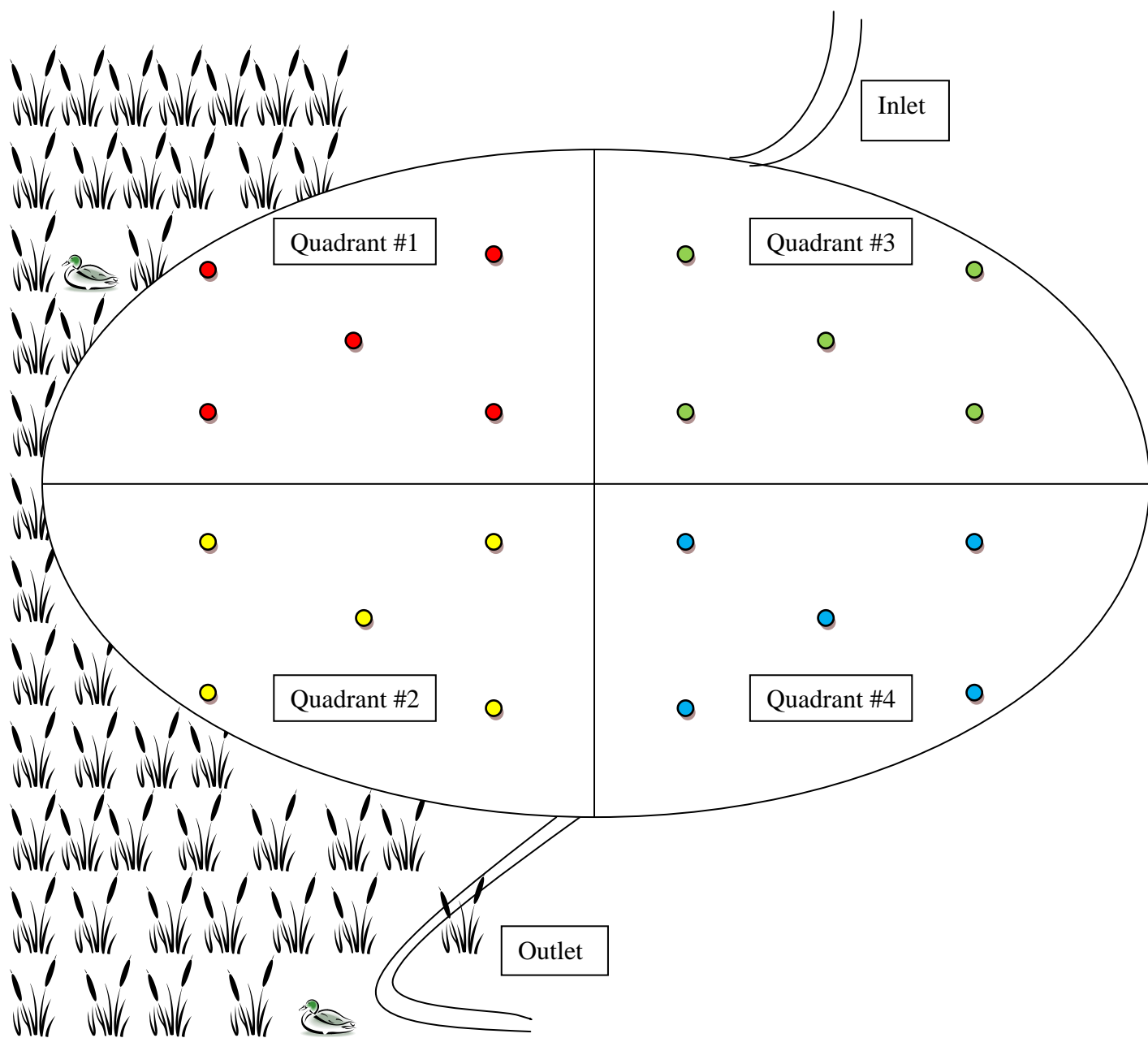


Figure A-1. Sediment sampling scheme for a stormwater pond greater than four acres in size.

Table A-1. List of PAHs to be Analyzed in Stormwater Pond Sediments

PAH Compounds Included in EPA Method 8270	cPAHs	U.S. EPA Group B2 Probable Human Carcinogens
Acenaphthene		
Acenaphthylene		
Anthracene		
Benzo[a]anthracene	X	X
Benzo[a]pyrene	X	X
Benzo[b]fluoranthene	X	
Benzo[j]fluoranthene	X	X
Benzo[e]pyrene		
Benzo[g,h,i]perylene		
Benzo[k]fluoranthene	X	X
Benzo[fluoranthenes (Total)		
Carbazole		
2-Chloronaphthalene		
Chrysene	X	X
Dibenz[a,h]acridine	X	
Dibenz[a,h]anthracene	X	X
Dibenzo[a,e]pyrene	X	
Dibenzo[a,h]pyrene	X	
Dibenzo[a,i]pyrene	X	
Dibenzo[a,l]pyrene	X	
7H-Dibenzo[c,g]carbazole	X	
Dibenzofuran		
7,12-Dimethylbenz[a]anthracene	X	
Fluoranthene		
Fluorene		
Indeno[1,2,3-cd]pyrene	X	X
3-Methylcholanthrene	X	
5-Methylchrysene	X	
1-Methylnaphthalene		
2-Methylnaphthalene		
Naphthalene		
Perylene		
Phenanthrene		
Pyrene		

Note: A combination of benzo[b]fluoranthene, benzo[j]fluoranthene, and/or benzo[k]fluoranthene frequently coelute together when sediments are analyzed.

Table A-2. Percent of Detected cPAHs in a MPCA Study of Metro Area Stormwater Ponds (Crane in review)\*

Parameter	# of Detects**	% Detected
Chrysene	44	73.3
Benzo[b&j]fluoranthene	42	70.0
Benzo[a]pyrene	41	68.3
Indeno[1,2,3-c,d]pyrene	38	63.3
Benzo[a]anthracene	34	56.7
Benzo[k]fluoranthene	34	56.7
Dibenzo[a,e]pyrene	33	55.0
Dibenzo[a,i]pyrene	32	53.3
Dibenzo[a,h]pyrene	23	38.3
Dibenzo[a,h]anthracene	15	25.0
Dibenz[a,h]acridine	10	16.7
3-Methylcholanthrene	4	6.7
Dibenzo[a,l]pyrene	4	6.7
5-Methylchrysene	1	1.7

\* Sediment samples were analyzed by a local commercial laboratory without using clean-up columns. Instead, the sample extracts were diluted to remove chemical interferences. The reporting limits were elevated as a result of diluting the sample extracts. A higher percentage of detected cPAHs probably would have been achieved if the sample extracts had been run through clean-up columns.

\*\* Results exclude field replicate data; n = 60 samples.

The following cPAHs were not detected in any samples: 1,6-Dinitropyrene, 1,8-Dinitropyrene, 1-Nitropyrene, 2-Nitrofluorene, 4-Nitropyrene, 5-Nitroacenaphthene, 6-Nitrochrysene, 7,12-Dimethylbenz(a)anthracene, 7H-Dibenzo(c,g)carbazole, and Dibenz(a,j)acridine.

Note: the MPCA evaluated this list of 25 cPAHs to determine if some of these cPAHs could be dropped from the analytical list for stormwater pond sediments. As indicated in Appendix B, this list of 25 cPAHs was adopted from an air quality program at California EPA. However, not all of these atmospheric cPAHs in California may be of concern in stormwater pond sediments in Minnesota. The above data set was reviewed, in addition to the percentage of detected cPAHs in other sediment data sets available to the MPCA (including some other metro-area stormwater pond sediments and sites included under the MPCA's Remediation Program). Additional input to the MPCA's evaluation came from recommendations from the Minnesota Department of Health for cPAHs to analyze in stormwater pond sediments, as well as human health-based toxicity data, environmental fate information, the results of the MPCA's environmental forensic work to determine sources of PAHs in metro-area stormwater ponds (Crane in review), and commercial production information. All of this information was used to shorten the list of cPAHs from 25 to 17 compounds (Table A-1). As additional data become available, the MPCA will periodically assess whether further changes are needed to this list.

## Attachment 1. Data quality indicators

This section is based on quality assurance/quality control (QA/QC) guidance provided by the U.S. Environmental Protection Agency (USEPA 2002). Data Quality Indicators (DQIs) are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of data. The principal DQIs are precision, bias, representativeness, comparability, and completeness. Establishing acceptance criteria for the DQIs sets quantitative goals for the quality of data generated in the analytical measurement process.

### Precision

Precision is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions. This agreement is calculated as either the range (R) or as the standard deviation (s). It may also be expressed as a percentage of the mean of the measurements, such as relative percent difference (RPD) or relative standard deviation (RSD) (for three or more replicates).

Field precision is assessed through the collection and measurement of field replicates at a rate of one replicate per ten analytical samples. This allows intralaboratory precision information to be obtained on sample acquisition, handling, shipping, storage, preparation, and analysis. Both samples can be carried through the steps in the measurement process together to provide an estimate of short-term precision. An estimate of long-term precision can be obtained by separating the two samples and processing them at different times or by different people and/or analyzed using different instruments.

For duplicate measurements, relative percent difference (RPD) is calculated as follows:

$$RPD = \frac{|D_1 - D_2|}{(D_1 + D_2)/2} \times 100\%$$

RPD = relative percent difference

D<sub>1</sub> = sample value

D<sub>2</sub> = duplicate sample value

|D<sub>1</sub> - D<sub>2</sub>| = absolute value of the sample minus the duplicate sample values

For three or more replicates:

$$RSD = (s/x) \times 100$$

RSD = relative standard deviation

s = standard deviation of three or more results

x = mean of three or more results

Standard deviation is defined as follows:

$$s = \left( \frac{\sum (y_i - \text{mean } y)^2}{n-1} \right)^{0.5}$$

s = standard deviation

y<sub>i</sub> = measured value of the ith replicate

mean y = mean of replicate measurements

n = number of replicates

### Bias

Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction. Bias assessments for environmental measurements are made using personnel, equipment, and spiking materials or reference materials as independent as possible from those used in the calibration of the measurement system. When possible, bias assessments should be based on analysis of

spiked samples rather than reference materials so that the effect of the matrix on recovery is incorporated into the assessment. A documented spiking protocol and consistency in following that protocol are important to obtaining meaningful data quality estimates. Spikes should be added at different concentration levels to cover the range of expected sample concentrations. The use of spiked surrogate compounds for GC/MS (SIM) procedures for PAH compounds are used to assess for bias.

## Accuracy

Accuracy is a measure of the closeness of an individual measurement of the average of a number of measurements to the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that result from sampling and analytical operations.

Accuracy in the field is assessed through the adherence to all sample handling, preservation, and holding times. In order to assure the accuracy of the analytical procedures, an environmental sample will be randomly selected from each sample shipment received at the laboratory, and spiked with a known amount of the analytes to be evaluated. In general, a sample spike will be included in every set of 20 samples tested on each instrument. The spike sample will then be analyzed. The increase in concentration of the analyte observed in the spiked sample, due to the addition of a known quantity of the analyte, compared to the reported value of the same analyte in the unspiked sample determines the percent recovery. The percent recovery for a spiked sample is calculated according to the following formula:

$$\%R = 100\% \times (S-U)/C_{sa}$$

%R = percent recovery

S = measured concentration in spiked sample

U = measured concentration in unspiked sample

C<sub>sa</sub> = actual concentration of spike added

For situations where a standard reference material (SRM) is used in addition to a matrix spike:

$$\%R = 100\% \times C_m/C_{srn}$$

%R = percent recovery

C<sub>m</sub> = measured concentration of SRM

C<sub>srn</sub> = actual concentration of SRM

## Representativeness

Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a qualitative term that should be evaluated to determine whether *in situ* and other measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the media and phenomenon measured or studied.

For field data, representativeness is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the field sampling plan is followed and that proper sampling techniques are used.

Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing laboratory duplicates for the chemistry samples.

## Comparability

Comparability is the qualitative term that expresses the confidence that two data sets can contribute to a common analysis and interpolation. Comparability must be carefully evaluated to establish whether two data sets can be considered equivalent in regard to the measurement of a specific variable or groups of variables. In a laboratory analysis, the term comparability focuses on method type comparison, holding times, stability issues, and aspects of overall analytical quantitation.

There are a number of issues that can make two data sets comparable, and the presence of each of the following items enhances their comparability:

- Two data sets should contain the same set of variables of interest;
- Units in which these variables were measured should be convertible to a common metric;
- Similar analytical procedures and quality assurance should be used to collect data for both data sets;
- Time measurements of certain characteristics (variables) should be similar for both data sets;
- Measuring devices used for both data sets should have approximately similar detection levels;
- Rules for excluding certain types of observations from both samples should be similar;
- Samples within data sets should be selected in a similar manner;
- Sampling frames from which the samples were selected should be similar; and
- Number of observations in both data sets should be of the same order or magnitude.

These characteristics vary in importance depending on the final use of the data. The closer two data sets are with regard to these characteristics, the more appropriate it will be to compare them. Large differences between characteristics may be of only minor importance, depending on the decision that is to be made from the data.

## Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Field completeness is a measure of the amount of valid measurements obtained from all the measurements taken in the project. Field completeness for sampling stormwater ponds should be greater than 95%. Laboratory completeness is a measure of the amount of valid measurements obtained from all the measurements taken in the project. Laboratory completeness should be greater than 95% of the total number of samples submitted to the analytical laboratories.

The calculation for percent completeness is as follows:

$$\%C = 100\% \times (V/n)$$

%C = percent completeness

V = number of valid measurements

n = number of measurements planned

## Reference

USEPA. 2002. Guidance for quality assurance project plans. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC. EPA/240/R-02/009. (<http://www.epa.gov/quality/qs-docs/g5-final.pdf>)

## Appendix B: Technical Guidance for Calculation of Benzo[a]pyrene Equivalents and Comparison of Chemical Concentrations to Soil Reference Values

This technical guidance provides instructions for calculating benzo[a]pyrene (B[a]P) equivalents for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) and guidance for comparing all chemical data from stormwater pond sediment samples to the MPCA's Soil Reference Values (SRVs). Management options for upland disposal of excavated sediment are discussed relative to the SRV values.

### Calculating B[a]P equivalents

The Minnesota Department of Health (MDH) recommends evaluating the 25 cPAHs that the California Environmental Protection Agency (Cal/EPA) has identified as being probable or possible human carcinogens (Cal/EPA 1993, 2009; MDH 2001). Since toxicity data does not exist for all individual cPAHs, they are evaluated according to how potent they are in relation to a reference contaminant, B[a]P. Assuming B[a]P has a toxicity of one, other cPAHs are assigned a potency equivalency factor (PEF) to indicate how toxic they are in comparison to B[a]P. Table B-1 lists B[a]P PEFs for 17 cPAHs to be measured in stormwater pond sediments (see Appendix A, Table A-2 for additional explanation). This section only pertains to cPAHs, which are evaluated by using B[a]P equivalents. Noncarcinogenic PAHs are evaluated individually and are not included in the total B[a]P equivalent concentration.

Table B-1. B[a]P Potency Equivalency Factors (PEFs)

cPAH	PEF	cPAH	PEF
Benz[a]anthracene*	0.1	Dibenzo[a,e]pyrene	1
Benzo[b]fluoranthene	0.1	Dibenzo[a,h]pyrene	10
Benzo[j]fluoranthene	0.1	Dibenzo[a,i]pyrene	10
Benzo[k]fluoranthene	0.1	Dibenzo[a,l]pyrene	10
<b>Benzo[a]pyrene**</b>	<b>1.0</b>	7,12-Dimethylbenzanthracene	34
Chrysene	0.01	Indeno[1,2,3-c,d]pyrene	0.1
Dibenz[a,h]acridine	0.1	3-Methylcholanthrene	3
Dibenz[a,h]anthracene	0.56	5-Methylchrysene	1
7H-Dibenzo[c,g]carbazole	1		

\*A common synonym for this compound is Benzo[a]anthracene

\*\*Benzo[a]pyrene is the reference contaminant

Site sediment concentrations of individual cPAHs are multiplied by the corresponding PEF value in Table B-1 to obtain an individual B[a]P equivalent concentration. These individual B[a]P equivalent concentrations are summed for all cPAHs to arrive at a total B[a]P equivalent concentration that is compared to the appropriate SRV value. The MPCA has developed an Excel file spreadsheet that users can add their detected cPAH data to calculate B[a]P equivalents. The "BaP equiv. calculation" worksheet is provided in the "Summary of Stormwater Pond Sediment Results" Excel file under the "Permit and Program Forms" section of the Stormwater webpage at: <http://www.pca.state.mn.us/sbiza7c>.

For example, Table B-2 shows how the B[a]P equivalents were calculated for a hypothetical stormwater pond where all 17 cPAHs were detected in the sediment sample. The contaminant concentrations are entered into Column C. Each cPAH concentration is multiplied by the corresponding PEF value in Column B to arrive at the individual B[a]P equivalent concentration in Column D. The individual B[a]P equivalent concentrations are then summed to obtain the total B[a]P equivalents concentration listed at the bottom of Column D.

Table B-2. Example – Calculating Total B[a]P Equivalents for Detected cPAH Data

A cPAH Compound	B PEF Potency Equivalent Factor	C Sediment Concentration (mg/kg)	D B[a]P Equivalent (mg/kg)
Benz[a]anthracene	0.1	2.190	0.219
Benzo[b]fluoranthene*	0.1	3.750	0.375
Benzo[j]fluoranthene*	0.1	0.000	0.000
Benzo[k]fluoranthene	0.1	1.320	0.132
Benzo[a]pyrene	1	2.270	2.270
Chrysene	0.01	2.790	0.028
Dibenz[a,h]acridine	0.1	0.219	0.022
Dibenz[a,h]anthracene	0.56	0.270	0.152
7H-Dibenzo[c,g]carbazole	1	0.160	0.160
Dibenzo[a,e]pyrene	1	0.828	0.828
Dibenzo[a,h]pyrene	10	0.419	4.190
Dibenzo[a,i]pyrene	10	0.391	3.910
Dibenzo[a,l]pyrene	10	0.150	1.500
7,12-Dimethylbenzanthracene	34	0.150	5.137
Indeno[1,2,3,-c,d]pyrene	0.1	1.350	0.135
3-Methylcholanthrene	3	0.170	0.512
5-Methylchrysene	1	0.160	0.160
Total B[a]P equivalents =			19.730

\* In this example benzo[b]fluoranthene and benzo[j]fluoranthene coeluted. In other words, the combined concentration of both cPAHs was reported by the laboratory as 3.75 mg/kg benzo[b and j]fluoranthene. Since both compounds have the same PEF value, 3.75 was entered for the sediment concentration of benzo[b]fluoranthene while the concentration of benzo[j]fluoranthene was entered as zero.



### **New procedure for addressing nondetect data when calculating B[a]P equivalents:**

It is unlikely that all 17 cPAHs will be detected in stormwater pond sediments (e.g., see Table A-2 in Appendix A). Previously, the MPCA's Stormwater Program recommended using one-half the reporting limit for nondetect data. However, this substitution method introduces bias in the results and can artificially inflate the B[a]P equivalent concentrations. The MPCA now recommends the following procedures:

1. Calculate a screening total B[a]P equivalents concentrations with the detected and estimated (J-flagged) cPAH data. If the total B[a]P equivalents exceed 3.0 mg/kg (the current industrial SRV), then no further calculations are needed with the nondetect data.
2. If the screening total B[a]P equivalents are less than 3.0 mg/kg and the percentage of nondetect data for each sample are  $\leq 50\%$ , then the nondetect data need to be included in the calculation of total B[a]P equivalents. The MPCA recommends using Kaplan-Meier statistics for calculating total B[a]P equivalents from the detected, estimated, and nondetect data; this procedure works best when there are  $\leq 50\%$  nondetect data. Kaplan-Meier is a nonparametric statistical method, and no assumptions about the distribution of the data (whether they follow a normal or other distribution) need to be made (Helsel 2010, 2012). Kaplan-Meier has been shown to be superior to substitution methods for nondetect data. Dennis Helsel, a retired statistician from the U.S. Geological Survey, has developed user-friendly guidance on how to use Kaplan-Meier statistics. In particular, he published a paper in 2010 on how to sum nondetect and detected data for calculating a total value. His paper goes through a case study example showing how this can be done using environmental chemistry data (i.e., polychlorinated biphenyls, dioxins, and furans) and toxic equivalence factors to calculate toxic equivalence concentrations (this is analogous to using the sediment cPAH data and the PEFs to calculate the total B[a]P equivalents). His 2010 paper is freely available at: <http://onlinelibrary.wiley.com/doi/10.1002/ieam.31/full>. Reading this paper and following through with the examples will give people the training they need to do Kaplan-Meier statistics. In addition, Dennis Helsel has developed a free Excel worksheet for using Kaplan-Meier statistics at: <http://practicalstats.com/nada/nada/downloads.html>. He also offers training classes/webinars and has a new book that clearly describes procedures for using Kaplan-Meier statistics (Helsel 2012).
3. If the screening total B[a]P equivalents are less than 3.0 mg/kg and the percentage of nondetect cPAH data are  $\geq 50\%$ , then there are increased difficulties with estimating the portion of the total B[a]P equivalents from the nondetect data. In these cases, the MPCA recommends reporting the total B[a]P equivalents based on the measured and estimated data with a qualifier that states the percentage of nondetect cPAH data.
4. If all of the cPAH data are reported as not detected, then the B[a]P equivalents cannot be calculated. In these cases, the municipality should investigate the QA/QC procedures of the laboratory further to determine if they were adequate. Since PAHs are a ubiquitous class of contaminants, a quality laboratory should be able to detect at least some of the cPAHs, especially B[a]P, chrysene, and indeno[1,2,3-cd]pyrene.

The MDH is in the process of reevaluating their recommendations for calculating total B[a]P equivalents. Revised cPAH guidance is expected to be issued later this year. Additional information can be found on the MDH website at: <http://www.health.state.mn.us/divs/eh/risk/guidance/pahmemo.html>.

## Determining restrictions and proper management

The MPCA has developed human health-based SRVs for residential and industrial land use scenarios. Analytical results for metals, noncarcinogenic PAHs, and total B[a]P equivalents (for cPAHs) are compared to these SRVs to determine what restrictions are placed on the excavated sediment, including management options for upland disposal.

An Excel file spreadsheet containing the Residential and Industrial SRVs are provided in the “Summary of Stormwater Pond Sediment Results” Excel file under the “Permit and Program Forms” section of the Stormwater webpage at: <http://www.pca.state.mn.us/sbiza7c>.

If all metal, total B[a]P equivalent (cPAHs), and noncarcinogenic PAH concentrations in the sediment are below the corresponding Residential SRV values, this indicates exposure to the dredged sediment does not present an unacceptable risk to humans in a residential scenario and management options may include disposal of the excavated sediment in residential areas. If all metal, total B[a]P equivalent (cPAHs), and noncarcinogenic PAH concentrations in the sediment are below the corresponding Industrial SRV values, this indicates exposure to the dredged sediment does not present an unacceptable risk to humans in an industrial setting and management options may include disposal of the excavated sediment in industrial areas. If the metal, total B[a]P equivalent (cPAHs), or noncarcinogenic PAH concentrations in the sediment exceed the industrial SRVs, this indicates that a potential risk may exist from exposure to the sediments and appropriate management options are required for the excavated sediment. In this case, contact the Stormwater Program for further guidance.

### ***Soil Reference Values (SRVs):***

SRVs are derived to assess potential human health exposures from soil using a reasonable maximum exposure (RME) scenario. RME scenarios are intended to protect an entire population without being overly conservative by using reasonable upper bound estimates for the most sensitive exposure parameters and central tendency estimates for less sensitive exposure parameters.

SRVs are intended to evaluate both potential non-cancer and cancer risks associated with a contaminant present in the soil. Two separate SRV values are calculated for each contaminant, one for non-cancer risk and one for cancer risk. The final SRV value reported on the Residential or Industrial SRV spreadsheet is the lower of the two. In other words, it is the smallest concentration of the contaminant that could potentially pose either a non-cancer or cancer risk. For example, for contaminant “X”, if the non-cancer SRV is 10 mg/kg and the cancer SRV is five mg/kg, then the final SRV is reported as five mg/kg.

The SRVs are currently undergoing revision to ensure they incorporate the latest scientific toxicity data available. In particular, the SRV for total B[a]P equivalents will be revised to incorporate new toxicity data.

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