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Managing Stormwater Sediment Best Management Practices Guidance

MINNESOTA POLLUTION CONTROL AGENCY

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Contents

Stormwater sediment best management practices

This document provides guidance for stormwater collection and conveyance systems, which have been designed, constructed, operated, and maintained for the purpose of providing treatment of stormwater.

Revisions since June of 2015

- Land use category definitions have been revised.
- Minor changes have been made to the "Stormwater Sediment Spreadsheet" to make the spreadsheet easier to use when calculating benzo[a]pyrene (B[a]P) equivalents and comparing contaminant concentrations in stormwater sediment to soil reference values.
- Sediment sampling is required regardless of the volume of sediment to be excavated.
- Minor changes have been made to the section "Determination of excavated soil as regulated solid waste".
- General information about hydraulic dredging has been added.

Stormwater collection and conveyance systems help protect infrastructure from flooding and they 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 stormwater collection and conveyance systems should be expected and sampling is required prior to disposal, or use (e.g. fill, topsoil, or compost) to determine proper management.

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 BaP equivalents for carcinogenic polycyclic aromatic hydrocarbons (cPAHs).
- Management requirements for contaminated sediment where contaminated stormwater sediments are accepted for disposal.

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:

- Proximity to high value resources or sensitive ecological features
- Landscape variations, and soil types
- Management of native or invasive species
- A wide range of other variables that may be encountered from one municipality to the next, or one project to the next

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 contaminated stormwater 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 aromatic hydrocarbons (PAHs) are often responsible for the greatest contamination problems in stormwater pond sediment (Crane et al. 2010). Research conducted on stormwater pond sediments in the Minneapolis-St. Paul, Minnesota metropolitan area showed that PAHs are the primary contaminants of concern affecting disposal decisions (Polta et al. 2006; Crane et al. 2010). 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 where these products are used in the surrounding watershed (Mahler et al. 2012). The Minnesota Pollution Control Agency's (MPCA) research (Crane 2014) determined that coal tar-based sealants were the most important source of PAHs (67.1%), followed by vehicle emissions (cars and trucks) (29.5%) and pine wood combustion (3.4%).

The Legislation also provided funding for municipalities who pass ordinances banning or restricting the use of coal tar-based sealants. Twenty-nine municipalities passed such ordinances before legislation in the spring of 2013 banned coal tar-based sealants state wide effective January 1, 2014 (Minn. Stat. § 116.202).

The 2009 Legislation also directed the MPCA to develop stormwater best management practices (BMPs) to avoid or mitigate impacts of PAH contamination from coal tar-based sealants. The MPCA provides guidance for the operation and maintenance of constructed stormwater collection systems. BMPs can be found in the Minnesota Stormwater Manual at this location http://stormwater.pca.state.mn.us/index.php/Main_Page.

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 that have been designed, constructed, operated and maintained for the purpose of providing treatment of stormwater.

Sediment removal from lakes, rivers, streams, and wetlands may be subject to additional requirements such as a permit from the Minnesota Department of Natural Resources (DNR) to allow work below the ordinary high-water level. Permit determinations are guided by DNR hydrologists based on geographical location. A list of DNR hydrologists by area is available on the DNR website at http://files.dnr.state.mn.us/waters/area_hydros.pdf.

Sediment may also be generated in other stormwater collection devices such as rain gardens, infiltration swales, sumps, traps, pipes, and/or other conveyance structures. This guidance may be adapted for other situations to determine representative contaminant concentrations. 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 that have been designed, constructed, operated, and maintained for the purpose of providing treatment of stormwater.

Sediment disposal costs

The high cost to manage contaminated stormwater sediment has brought operation and maintenance of stormwater ponds into the public spotlight. Disposal costs for stormwater sediment removal projects with contamination exceeding the industrial soil reference values is regulated as a solid waste and the cost for disposal can be as much as three times more expensive than uncontaminated sediment depending on the type and level of contamination. The high cost to manage contaminated sediment emphasizes the importance of source control to reduce the loading of contamination into stormwater ponds.

Sediment removal process

Inventory and maintenance needs.

Evaluating and testing sediment.

Engineering, contracting, and work plans.

Excavating sediment.

Site restoration.

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:

- Have priorities been identified by city inspections – sediment level, lost capacity, other needs?
- Accessibility. Does the city already have access via parkland, easement, or outlot? Are there access points for machinery and trucks?
- 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, or redesigned to provide greater benefit?
- Is surveying needed to assess lost capacity and depth of excavation?
- How will you measure or estimate the volume of sediment to be removed?
- Have sediment deltas and inlet/outlet structures been identified/located?
- 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

Sediment samples are collected and compared to MPCA's Remediation Division soil reference values (SRVs) to determine where excavated sediment may be used or disposed. This affects work plan development, including contract specifications for bidding projects and is an important part of the management process.

- Guidance for *collecting samples* and *testing sediment* is summarized in Appendix A.
- Guidance for *comparing contaminant* analytical data (concentrations) to *SRVs* and calculating *B[a]P equivalents* is summarized in Appendix B.

There are three levels of dredged material based on SRV levels, and two associated land use categories:

Level 1 dredged material

Residential land use- Excavated sediment with all contaminants at or below a Level 1 SRV

Level 1 Dredged Material is characterized as being at or below analyte concentrations for all the Residential/Recreational SRVs listed in the Residential/Recreational SRV column of the spreadsheet "Summary of stormwater pond sediment testing results".

Level 1 dredged material may be used on lawn surrounding single family homes, multi-family housing, condominiums, long-term care facilities, correctional housing, hospitals, hotels, office buildings, retail stores, shopping centers, and restaurants, and industrial property, public utility facilities, rail and freight facilities, storage facilities, warehouses, office buildings, and manufacturing facilities.

Do not place level 1 dredged material where food for human/animal ingestion will be grown. Do not place level 1 dredged material in areas where children may come into contact with the material. A minimum ten-foot separation distance between dredged material and the water table is recommended. Avoid placing level 1 dredged material where contaminants may be transported by run-off to lakes, rivers, wetlands, or streams.

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

Level 2 dredged material

Industrial and commercial land use- one or more contaminants at a Level 2 SRV, or between Level 1 and Level 2

Excavated sediment is determined to be level 2 dredged material and regulated solid waste when one or more of the required list of analytes, including cPAHs expressed as B[a]P equivalents and any other site-specific contaminants, exceed the Residential/Recreational SRVs but do not exceed the Commercial/Industrial SRVs. The excavated sediment may be used on industrial/commercial land or sent to a solid waste landfill (see Level 3 dredged material).

Level 2 dredged material may be used on lawns, yards, and landscaping that surround hotels, office buildings, retail stores, shopping centers, and restaurants and industrial property, public utility facilities, rail and freight facilities, storage facilities, warehouses, office buildings, and manufacturing facilities.

Do not place level 2 dredged material in residential settings. Do not place level 2 dredged material where food for human/animal ingestion will be grown. A minimum ten-foot separation distance between dredged material and the water table is recommended. Do not place level 2 dredged material where contaminants may be transported by run-off to lakes, rivers, wetlands, or streams.

Level 3 dredged material

No appropriate land use- one or more contaminants above Level 2 SRV

Excavated sediment with no appropriate land use must go to a landfill. 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 including a liner and a leachate collection system.

MSW landfills in Minnesota that can accept contaminated sediment are listed at this webpage:

http://www.pca.state.mn.us/veiz806 or, the list can be accessed directly at this link: https://www.pca.state.mn.us/sites/default/files/w-sw6-04.pdf

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

Guidance for analytical data comparing contaminants to SRVs and calculating B[a]P equivalents are summarized in Appendix B. At this time, testing sediment for metals other than copper and arsenic is not required. However, contractors who remove and/or transport sediment, or facilities that re-use or dispose of sediment may require test results for heavy metal concentrations. This may be an important variable as sediment removal projects are planned and samples are collected and compared. It is recommended that you consult with contractors and contact disposal or re-use facilities to ensure they will be able to accept your waste and to determine what additional sampling requirements (if any) may be required by the facility.

In some cases, a Level 3 Dredged Material may have levels 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 levels in sediment are 50 mg/kg or greater. In these cases, significant additional regulation applies, and disposal of the waste is strictly regulated.

Multiple dredged material levels

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 able to be managed differently from each other, depending on the Management Level applicable to each discrete 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 project, such as at a use/reuse staging area, are co-mingled prior to disposal.

See Appendix A for guidance on sampling.

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 DNR. The MPCA does not require a permit or notification for routine maintenance of stormwater ponds. Cities are advised to keep records and documentation of their sediment removal projects as outlined in this guidance and as required by the Municipal Separate Storm Sewer Systems (MS4) Permit. A permit from the MPCA is required if projects will disturb one or more acres upland. Projects disturbing one or more acres upland are required to have a Construction Stormwater Permit.
- 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 can take place during the winter or summer.

Benefits to sediment removal projects in the winter 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. 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. Cleanup and removal of temporary infrastructure should be done working your way out of the site. Once equipment and temporary infrastructure (such as transport roads and rock entrances) is removed, it will be cost prohibitive and essentially impossible to make additional corrections.

Summer excavations include the risk of unexpected rainfall events that can complicate a conventional sediment removal project and sometimes delay the project for days and increase the risk to receiving waters down-stream. Small projects (less than one acre) may be completed in one day or less and risks associated with unexpected rainfall events can be minimized or avoided altogether. Small projects do not require a permit, but safeguards and best management practices are still required to ensure negative down-stream impacts to receiving waters are prevented. Large projects that will disturb one or more acres upland are required to have a Construction Stormwater Permit to ensure BMPs are implemented as the scale of the project and potential risks to receiving waters increase.

One method of sediment removal that can be used during the summer months is called hydraulic dredging. This process utilizes a watercraft or floating dredging device with a large centrifugal pump to remove sediment. Saturated mud and sand (often referred to as muck) is removed from the stormwater pond and discharged into a large filter bag (or series of bags) upland. This process may allow sediment to be pumped hundreds and sometimes thousands of feet away from the pond depending on site conditions. Water that drains from the filter bag is channeled to a secondary treatment system with a flocculent that provides additional filtration before the water is returned to the stormwater pond. Benefits to hydraulic dredging include:

- Allows work to be performed during warm weather conditions.
- May be better suited for sites that are difficult to access with large trucks or large machinery.
- In many cases, it will result in less disturbance for neighbors as the dredging operation is generally more quiet than operating various types of heavy machinery.
- Impacts to reptiles (turtles) and amphibians (frogs) may be less as they are not hibernating in the sediment and are able to move away from the slow-moving dredge.
- Filter bags and treatment of the water that drains from them reduce fugitive dust and provide a secure way to store sediment while the sediment dries out.
- No need to bypass flows in the watershed, which can be difficult if the watershed draining to the pond is large.
- Hydraulic dredging can take place even when there are significant groundwater inputs to the pond.
- Scheduling and costs are typically more predictable and are not likely to vary as they might with conventional excavation methods.

- Hydraulic dredging has a longer working season. Sediment removals via hydraulic dredging can be performed roughly eight months of the year depending on site conditions and seasonal variations from year to year.
- Hydraulic dredging projects are not impacted by rainfall and can continue operations during rainfall if desired.

Hydraulic dredging projects also have a few drawbacks. They include:

- Segregating specific areas of the pond by contaminate levels may be difficult or impossible.
- The necessary area needed for dewatering and storage may not be available depending on the specific site.
- In drought, years there may be too little water in the pond to effectively float and propel the dredge.
- Projects are typically more expensive than conventional excavation methods.
- Sediment pumped to filter bags must be handled a second time when the bags are opened and sediment is loaded into trucks for transportation off site.
- Grinding or mulching dense vegetation can be a messy and difficult process when large amounts of woody debris (logs, stumps) are encountered. Dense vegetation can slow down the dredging process and it may also increase time and cost.

Regardless of method, survey work is usually conducted to better estimate the amount of sediment to be removed and to identify the depths of excavation in order to restore desired capacity. If the removal volume is not defined by surveying then establishing a standard volume per truck and calculating the volume based on truck loads leaving the site can be used to track the volume in cubic yards.

Excavating or removing sediment from stormwater collection systems requires care to prevent turbid water and pollutants from impacting down-stream waters such as wetlands, streams, rivers, or lakes. This is just as true for winter sediment removal projects as it is for projects conducted during the summer months.

5. Site restoration and erosion control

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

- Additional cleanup 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.

Erosion control (temporary and permanent) are typically incorporated into plans and specifications for stormwater sediment removal projects. Permanent erosion-control features may include provisions for:

- Vegetative buffer strips around the pond.
- Design of grassed waterways and overflow channels.
- Armoring of spillways and banks, or other features needed to prevent erosion for the life cycle of the stormwater collection and conveyance system.

Temporary erosion control features may include provisions such as mulch, tackifiers, or erosion control blankets to prevent erosion until seeding takes root and vegetation becomes established. Erosion of banks, side slopes, safety benches, spillways, outfalls, channels, and adjacent upland areas disturbed by machinery are all priority areas during site restoration. These areas should be stabilized as quickly as possible to prevent erosion.

Areas susceptible to erosion should be inspected frequently following a sediment removal project. If erosion occurs, the eroded areas should be restored as quickly as possible. If erosion persists, action must be taken immediately to protect downstream receiving wasters with permanent erosion control. Permanent features may include:

- Bioengineering strategies
- Turf reinforcement mats
- Vegetated-concrete-block-armoring
- Properly sized riprap and filter materials

Vegetated buffer strips (25 feet or more) are recommended to surround the stormwater pond (whenever possible) to prevent erosion from the pond's immediate tributary. Establishing vegetation not only helps maintain the integrity of the pond, it also helps with the ponds overall appearance. Establishing vegetation is important, but care should be taken to prevent trees, shrubs, or brush from growing within 15 feet of the toe of the embankment, or 25 feet from the inlet and outlet structures. Roots can damage pipes and other infrastructure, but trees and shrubs can also clog inlets and outlets and prevent the stormwater pond from functioning properly.

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:

- Inspection dates and frequency of inspections (Required by MS4 Permit)
- Description of maintenance and dates performed (Required by MS4 Permit)
- The unique ID# of the pond (Required by MS4 Permit)
- Employee training records (Required by MS4 Permit)
- Volume of sediment removed in cubic yards (Required by MS4 Permit)
- Evaluation, testing, and/or laboratory results (Required by MS4 Permit)
- Place of disposition/disposal (Required by MS4 Permit)
- "As Built" prints or plans if they exist
- The name and geographical location of the pond with reference to nearest cross roads.
- Contractor information, shipping papers/manifests/contractual agreements.
- Any other observations about the sediment removal, or work performed, that will help the city operate and maintain that site in the future.

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Appendix A: Sediment sampling and analytical technical guidance

This technical guidance should be shared with 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.

Sediment sampling

The U.S. Environmental Protection Agency's (EPAs) report on "Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual" (EPA 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, checklists, 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. Stormwater ponds also vary in size and shape, and some ponds 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 2014), coal tar-based sealant sources comprised 67.1% of total PAHs in surface sediments of ponds located primarily in residential, commercial, and industrial land use areas. Higher concentrations of PAHs will occur in stormwater pond sediments in watersheds where coal tar-based sealants are used on driveways and parking lots than in watersheds where either asphalt-based sealants (which have much lower concentrations of PAHs), no sealant, or other material such as concrete, permeable pavers, or gravel are used for driveways and parking lots. Even though a statewide ban on coal tar-based sealants went into effect January 1, 2014, in Minnesota, abraded coal tar-based sealant particles from existing driveways and parking lots will continue to wash off into stormwater collection and conveyance systems for years to come. As these parking lots and driveways are sealed with asphalt-based sealants in the future, and with the elimination of new applications of coal tar-based sealants, concentrations of PAHs in sediment deposits are expected to decrease over time.

The MPCA requires owners or responsible parties to sample sediments prior to disposal to determine concentrations of 17 cPAHs, 10 noncarcinogenic PAHs, and the metals arsenic and copper. A list of the specific cPAHs and noncarcinogenic PAHs can be found in MPCA's "Summary of Stormwater Pond Sediment Testing Results" spreadsheet available on MPCA's Coal tar-base sealants web page at: Coal tar-based sealants | Minnesota Pollution Control Agency (state.mn.us). Scroll down to the heading "Sediment removal guidance". 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 is 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 (example, nickel from a metal plating facility), the owner or responsible party should include those contaminants on the list for sampling.

Analysis of sediment samples for particle size and total organic carbon (TOC) is optional, but this information may be useful for some reuse scenarios of the excavated sediment.

The analytical laboratory will provide guidance on the mass of sediment needed for each analysis. Field sampling should be conducted early in the process to provide timely assessments of management options. Sediment sampling for required analytical parameters must be conducted regardless of the volume of sediment to be excavated from the pond.

General guidance for characterizing sediment is as follows:

- **Sampling depth:** 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 the responsibility of the owner or responsible party to collect sediment samples that will cover the depth to be dredged. If field sample collection is simpler over two-foot depth intervals, then by all means continue to do this. The important issue is to submit 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.
- **Sampling equipment:** Core samplers are more appropriate to use to obtain cohesive sediment samples at a 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.
- **Sampling location data:** Geopositional (GPS) coordinates need to be collected at the location of each sample site.
- **Sample number and design:** The number of samples to be collected depends on the surface area of the pond and/or the area of planned dredging. [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 not be detected in all areas of the pond.
- **Dredging area - one acre or less:** For planned sediment removal within stormwater ponds or portions thereof with a surface area less than or equal to one acre, at least two locations (sites) need to be sampled for chemical analysis. Sample sites may be selected randomly or in a transect from the main inlet to the outlet of the pond. When sediment removal is targeted only for a certain location(s) within a pond (e.g., a sediment delta near an inlet), sample sites should be selected in the same manner except that the candidate areas for site selection should be defined by boundaries of the targeted area rather than the entire pond.
- **Dredging area - one to four acres:** For planned sediment removal within stormwater ponds or portions thereof having a surface area between one and four acres, one sampling site 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 site 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 the outlet of the pond. When sediment removal is targeted only for a certain location(s) within a pond (e.g., a sediment delta near an inlet), sample sites should be

selected in the same manner except that the candidate areas for site selection should be defined by boundaries of the targeted area rather than the entire pond.

- **Dredging area – greater than four acres:** For planned sediment removal within stormwater ponds or portions thereof that are larger than four acres, divide the area 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 homogenize (mixed well) in a precleaned container (large 4 L Pyrex mixing cups work well; larger volumes can use precleaned buckets). For a given quadrant, an equal aliquot of sediment from each associated subsample is then composited together to form the sediment sample for that quadrant that is submitted to the analytical laboratory. When sediment removal is targeted only for a certain location(s) within a pond (e.g., a sediment delta near an inlet), sample sites should be selected in the same manner except that the candidate areas for site selection should be defined by boundaries of the targeted area rather than the entire pond.
- **Dredging area – greater than four acres, irregularly shaped:** For natural ponds larger than four 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.
- **Field replicate samples:** To provide a measure of field precision, collect one field replicate sample for every 10 samples or less collected for analysis (i.e., 10% of samples should be collected in replicate). The goal of a replicate is to be as similar in space and time as one of your "primary" samples. Select the sample(s) to be replicated. One can generate a field replicate with surplus sediment from the cores/samples already collected for that sample, provided sufficient sediment remains. To create a replicate, repeat exactly the same procedures that were used to generate the selected sample, as near in time as possible to the primary sample (i.e., sample/subsample the same cores, masses, locations, and/or necessary processing steps). Adherence to the same procedures and timeline will enhance your analytical precision and results.
- **Sample collection, handling and processing (prior to submittal to laboratory) practices:**
  - 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.
  - Composite sediment samples in the field prior to splitting into the sample jars.
  - Sediment samples from stormwater ponds can vary in their consistency. Some samples may be loose ("soupy") if they contain much cattail or wetland plant detritus. In these cases, collect/subsample extra sediment to ensure the laboratory will have enough mass of sediment to conduct their analyses.
  - **Sample homogenization and splitting:** Sediment samples should be homogenized (mixed well) before splitting the sample into pre-cleaned jars for the PAH and metals analyses.
  - **Sample labeling and laboratory bottles:** The laboratory will provide pre-cleaned sample jars and labels for clients, including separate containers for PAHs, metals, and in some cases percent moisture analysis. Use a permanent marker to fill out the sample label. It is often helpful to pre-label your bottles (before adding sample) both to avoid confusion and the difficulty of attaching labels to wet surfaces. It is also helpful to wrap clear packing tape around the label to secure it on the jar because labels may easily come loose while on ice in coolers during transport.
  - **Sample percent moisture analysis:** Laboratories measure the percent moisture in the samples to convert the results to dry weight measurements. This may be billed as a separate

procedure. In some cases, the laboratory will provide a separate sampling container for percent moisture analysis.

- **Sample transport, storage, and tracking:** Store the sediment samples on ice in a cooler during field sampling. Sample tracking forms or chain-of-custody forms must be used 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 chain-of-custody forms.

Submit samples to analytical laboratories

At the end of each field sampling day, either transfer the samples directly to the analytical laboratory, which is preferred, or store them in an interim refrigerator or freezer (depending on the specifications of the laboratory) prior to submittal. Some laboratories may provide a courier pick-up service. When out-of-town laboratories are used, ship the samples on ice in sturdy coolers using an overnight courier; also use packing peanuts and consider wrapping each jar in bubble wrap.

The analytical laboratories will provide guidance on the holding times for samples based on the analytical parameter. Sediment samples can usually be frozen to extend the holding time, but care must be taken to only fill the sample jars two-thirds full to allow room for expansion while the sediment freezes.

To increase the success of the analytical work, follow these steps prior to submitting the sediment samples:

- **Remove excess water:** Even with decanting overlying water during field sampling, the sample jars may contain a layer of water over the sediment. This water needs to be removed prior to analysis. Either the field sampler (if the samples are stored overnight at an interim facility) or the analytical laboratory needs to remove this overlying water. Laboratory staff will not automatically do this step, and the client needs to specify if they want this accomplished. 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.
- **Matrix Spike/Matrix Spike Duplicate (MS/MSD) analysis:** To assess analyte recovery and precision, request/confirm that the laboratory will spike and analyze one Matrix Spike and one Matrix Spike Duplicate per 20 samples or less, as is usual standard practice. For the MS/MSD spike and recovery assessment, it is desirable to use “average” samples – e.g., samples that are not too clean or sandy but also not too dirty or full of organic matter. Provide guidance to the laboratory on which samples may meet this criterion, if possible. Otherwise, instruct the laboratory to use their best judgment or to randomly select sample(s) from those submitted to include in this assessment. *Note: if your budget allows, it is best to conduct an MS/MSD spike assessment for each pond being sampled, even if this means assessing more than the typical one-per-20 samples.*
- **Sample tracking/chain of custody:** Provide a copy of the sample tracking or chain of custody form to the analytical laboratory when the samples are submitted or shipped to them.

Considerations in Selecting an Analytical Laboratory:

Cooperative Purchasing Venture (CPV) program: Municipalities can access laboratory services through the Minnesota Department of Administration Cooperative Purchasing Venture (CPV) program. There is no charge to sign-up, and the CPV program is open to all municipalities. The CPV program allows municipalities to obtain laboratory services through state-negotiated contract prices. Municipalities who are not currently CPV members, but would like to become one, may sign-up for this program at the Minnesota Department of Administration's website at: http://www.mmd.admin.state.mn.us/cpv2.htm. The Minnesota Department of Administration's website contains a comprehensive list of state-negotiated contracts. The following contract is specific to sampling and laboratory analysis:

S-792(5) SAMPLING & LABORATORY ANALYSIS - ENVIRONMENTAL

Laboratories that will perform sample cleanup procedures: It is often necessary to reduce matrix interferences for sediment analysis. Typically, a sample cleanup or dilution step will be performed by the laboratory for this purpose. MPCA's position is that sample cleanup is the far better option for municipalities. Laboratories that do offer cleanup typically charge a small fee (a small fraction of the cost of PAH analysis). But in comparison with dilution, sample cleanup will result in better precision, lower reporting limits, and a concomitantly reduced risk of misclassifying sediments as Tier 2 or 3 dredge material. The extra cost for sample cleanup is miniscule in comparison to the potential, unnecessary cost of misclassification and unnecessary disposal at a landfill approved for contaminated sediments. MPCA recommends that responsible parties request that their laboratory provide this service, if not currently offered. Upon request, MPCA will provide references to laboratories that will perform cleanup.

Analytical methods

The primary analytical methods are provided below:

The extended list of PAHs (Table A-1), including 17 cPAHs and noncarcinogenic PAHs, must be analyzed based on the most recent final version of EPA SW-846 Method 8270 by gas chromatography/mass spectrometry (GC/MS) with selective ion monitoring (SIM) as an option.

- Analysis of stormwater pond sediment extracts will often result in compound or matrix interference that can affect analytical accuracy and precision. MPCA recommends sample extract cleanup instead of dilution (see above "Considerations in Selecting an Analytical Laboratory").
    - An example of a cleanup procedure to isolate the hydrocarbon fraction is to pass the sample extract through an alumina and/or silica gel.
    - Refer to the most recent final versions of EPA SW-846 Method 8270 and Method 3600 for guidance on appropriate cleanup techniques.
    - When sample extracts are subjected to cleanup procedures, the associated batch quality control samples, i.e., method blank, laboratory control sample (LCS), MS/MSD, etc., must also be subjected to the same cleanup procedures.
- The analytical laboratory must be asked to report PAHs that are in-between the method detection limit and the reporting limit and to qualify results as estimated.
- Metals should be analyzed by either inductively coupled plasma-optical emission spectrometry (ICP) or inductively coupled plasma—mass spectrometry (ICP—MS) using the most recent final version of EPA SW-846 Method 6010 or 6020.
- Sediment results must be reported on a dry weight basis.

- Information on TOC and particle size distribution within sediment samples can provide context to understand and anticipate PAH occurrences, because organic content and particle size/type affect the partitioning behavior of many contaminants. Although not required, these parameters may thus be of interest to practitioners when interpreting their data and planning future investigations. TOC can be analyzed using the most recent final version of EPA SW-846 Method 9060. Particle size can be analyzed multiple ways to determine percent sand, silt, and clay. If only the inorganic particle size fraction is of interest, then the sediment samples will need to be pretreated to remove organic matter. If organic matter is included in the analysis, then the "apparent" (i.e., organic plus inorganic) particle size distribution will be determined.

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. Establishing acceptance criteria for the DQIs sets quantitative goals for the quality of data generated in the analytical measurement process. See https://www.epa.gov/quality/guidance-quality-assurance-project-plans-epa-qag-5 for information on establishing DQIs.

For cPAHs and noncarcinogenic PAHs by EPA Method 8270, the DQIs set by the MPCA are:

- Blanks: analyte concentrations are less than the method detection limit or reporting limit, whichever is being used for quantitation; method blanks should be prepared with each analytical batch of 20 samples or less.
- Surrogate Recovery: approximately 30-150%, 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: approximately, 30-150%; 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.

For metals (arsenic and copper):

- Blanks: analyte concentrations are less than the reporting limit; method blanks should be prepared with each analytical batch of 20 samples or less.
- Precision (% RPD): <20%.
- Accuracy: LCS- 80-120%.
- MS/MSD: 75 – 125%, unless laboratory calculated limits are tighter.

Electronic data requirements

- Electronic copies of the data should be obtained from the analytical laboratory in spreadsheet format (e.g., Microsoft Excel). Laboratories will normally report sample concentrations down to the reporting limit. Request that the laboratory also report sample concentrations down to the method detection limit to ensure B[a]P equivalents can be calculated appropriately (Appendix B). Note that concentrations quantified between the method detection limit and the reporting limit should be flagged as "estimated".

References

Crane, J.L. 2014. Source apportionment and distribution of polycyclic aromatic hydrocarbons, risk considerations, and management implications for urban stormwater pond sediments in Minnesota, USA. Arch. Environ. Contam. Toxicol. 66:176-200

Stollenwerk, J., J. Smith, B. Ballavance, J. Rantala, D. Thompson, S. McDonald, and E. Schnick. 2011. Managing dredged materials in the State of Minnesota. Minnesota Pollution Control Agency, St. Paul, MN. MPCA document number wq-gen2-01. https://www.pca.state.mn.us/sites/default/files/wq-gen2-01.pdf

USEPA. 2001. Methods for collection, storage and manipulation of sediments for chemical and toxicological analyses: Technical manual. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-823-B-01-002 (https://www.epa.gov/ocean-dumping/methods-collection-storage-and-manipulation-sediments-chemical-and-toxicological).

USEPA "SW-846 Test Methods for Evaluating Solid Waste", Update IV of the Third Edition; Methods 6010, 6020, 8270. https://www.epa.gov/hw-sw846/sw-846-compendium

USEPA. 2002. Guidance for quality assurance project plans. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC. EPA/240/R-02/009 (https://www.epa.gov/sites/default/files/2015-06/documents/g5-final.pdf).

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

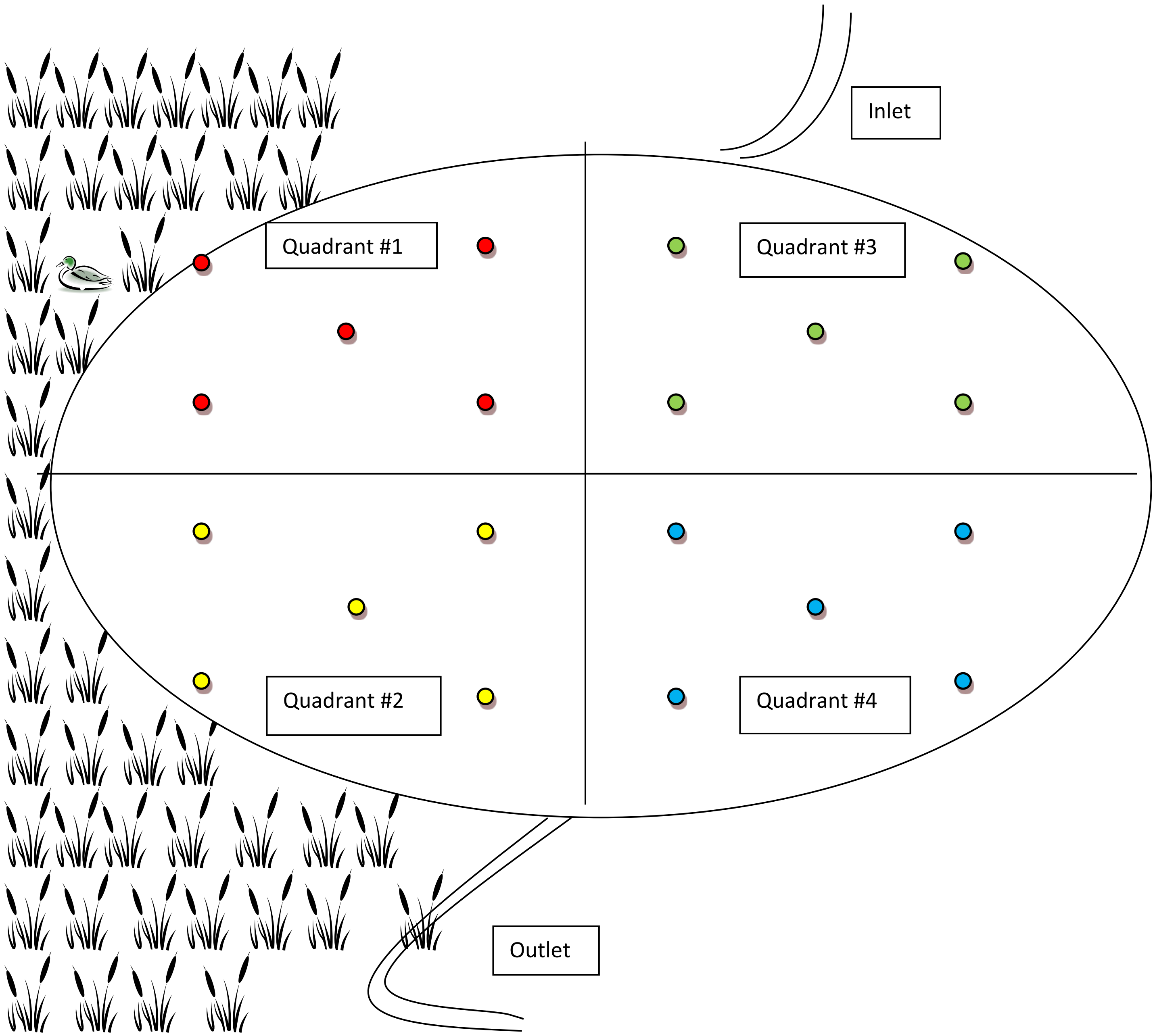


Table A-1. List of PAHs to be analyzed in stormwater pond sediments

Noncarcinogenic PAHs
Acenaphthene
Acenaphthylene
Anthracene
Benzo[g,h,i]perylene
Fluoranthene
Fluorene
2-Methylnaphthalene
Naphthalene
Phenanthrene
Pyrene
Carcinogenic PAHs
Benzo[a]anthracene
Benzo[b]fluoranthene
Benzo[j]fluoranthene
Benzo[k]fluoranthene
Benzo[a]pyrene
Chrysene
Dibenz[a,h]acridine
Dibenz[a,h]anthracene
7H-Dibenzo[c,g]carbazole
Dibenzo[a,e]pyrene
Dibenzo[a,h]pyrene
Dibenzo[a,i]pyrene
Dibenzo[a,l]pyrene
7,12-Dimethylbenz[a]anthracene
Indeno[1,2,3-cd]pyrene
3-Methylcholanthrene
5-Methylchrysene

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

Appendix B: Soil reference values and benzo[a]pyrene equivalents

Appendix B provides guidance for comparing contaminant concentrations from stormwater pond sediment to the MPCA's Remediation Division Soil Reference Values (SRVs) and instructions for calculating benzo[a]pyrene (B[a]P) equivalents for carcinogenic polycyclic aromatic hydrocarbons (cPAHs).

Comparing sediment contaminant concentrations to SRVs

Soil Reference Values (SRVs):

SRVs are risk-based values derived to assess potential human health exposures from soil at a Remediation cleanup site 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.

They are intended to evaluate both potential non-cancer and cancer risks associated with a contaminant present in soil. Two separate SRVs are calculated for each contaminant, one for non-cancer risk and one for cancer risk. The final SRV reported as the Residential or Industrial SRV 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 5 mg/kg, then the final SRV is reported as 5 mg/kg.

Since stormwater sediment removed from the stormwater pond is being evaluated for use on dry land as soil, SRVs are an appropriate conservative risk based values to evaluate potential human health risks.

"Summary of Stormwater Pond Sediment Testing Results" Spreadsheet:

MPCA's stormwater program "Summary of Stormwater Pond Sediment Testing Results" spreadsheet allows users to compare stormwater pond sediment data to SRVs. The spreadsheet is available on MPCA's Coal tar-based sealants web page at Coal tar-based sealants | Minnesota Pollution Control Agency (state.mn.us). Scroll down to the "Sediment removal guidance" heading.

The spreadsheet will open to the "BaP equiv. calculation" tab used to compare the data to the SRVs. There are three sections where data can be entered:

- Metals
- Noncarcinogenic PAHs
- Carcinogenic PAHs/ BaP Equivalents

Metals and noncarcinogenic PAHs

For metals and noncarcinogenic PAHs, follow the instructions listed below. For carcinogenic PAHs (cPAHs), follow the instructions listed under the "Calculating B[a]P Equivalents" section.

1. Enter the chemicals reporting limit into the "Reporting Limit", Column (B).
2. Enter the core location (sample) data (concentrations) under the "Sample Locations and Depths" columns under each "Core Location #" (E&F, G&H, I&J) for the site. Add additional core location columns if you have more than 3 core locations (samples).
3. Compare the chemical data (concentrations) under the "Sample Locations and Depths", "Core Location #" columns (E&F, G&H, I&J) to the "Residential SRV Values" and "Industrial SRV Values" columns (C, D).

Calculating B[a]P equivalents

Minnesota Department of Health Guidance

The Minnesota Department of Health (MDH) issued new guidance regarding the calculation of B[a]P equivalents (https://www.health.state.mn.us/communities/environment/risk/docs/guidance/pahguidance.pdf). Several new cPAHs were added to the required list to be analyzed that currently do not have analytical methods for soil. At this time, it is not feasible to adopt MDH's guidance for use with the Remediation Division's soil reference values (SRVs). MPCA will continue to use the potency equivalency factor (PEF) method previously recommended by MDH to evaluate human health risks from cPAHs until new analytical methods for soil are developed for the new cPAHs on the revised list.

MDH's previous recommendation was based on evaluating the 25 cPAHs that the California Environmental Protection Agency (Cal EPA) 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 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. 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
Benzo[a]pyrene	***1.0***	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 B[a]P SRV. 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 "Site Concentration" for each cPAH is entered into Column C. Each cPAH concentration is multiplied by the corresponding "Potency Equivalency Factor (PEF)" in Column B to arrive at the individual "BaP Equivalent" concentration in Column D. B[a]P equivalent concentrations are then summed to obtain the "Total BaP Equivalents" at the bottom of Column D.

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

A cPAH Contaminant	B Potency Equivalent Factor (PEF)	C Site Concentration mg/kg	D BaP 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 BaP 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 contaminants 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.

Carcinogenic PAHs (cPAHs):

For cPAHs, follow the instructions below. Please refer to Figure B-1 for a flowchart depicting the following process.

Step 1

If all of the cPAHs have been detected, follow the instructions below in Step 1. If not, proceed to Step 2.

- Use the "Summary of Stormwater Pond Sediment Testing Results" spreadsheet to calculate the B[a]P equivalent concentration for each of the cPAHs analyzed. The spreadsheet is available on MPCA's Coal tar-based sealants web page at Coal tar-based sealants | Minnesota Pollution Control Agency (state.mn.us). Scroll down to the "Sediment removal guidance" heading.
    1. The spreadsheet will open to the "BaP equiv. calculation" tab
    2. Under the "Carcinogenic PAHs/B[a]P Equivalents" section, enter the cPAHs reporting limit to the "Reporting Limit" Column (B).
    3. Enter the core location (sample) cPAH data (concentrations) under the "Sample Locations and Depths" column, "Core Location #", "Site Conc." columns (E, G, I). Add additional core location columns if you have more than three core locations (samples).

4. The spreadsheet automatically calculates the B[a]P equivalent concentration in the "BaP Equiv." columns (F, H, J).
5. Compare each samples "Total B[a]P equivalents" concentrations column (row 39, columns F, H, J) for each core location (sample) to the Residential and Industrial SRVs listed for B[a]P (columns C, D).

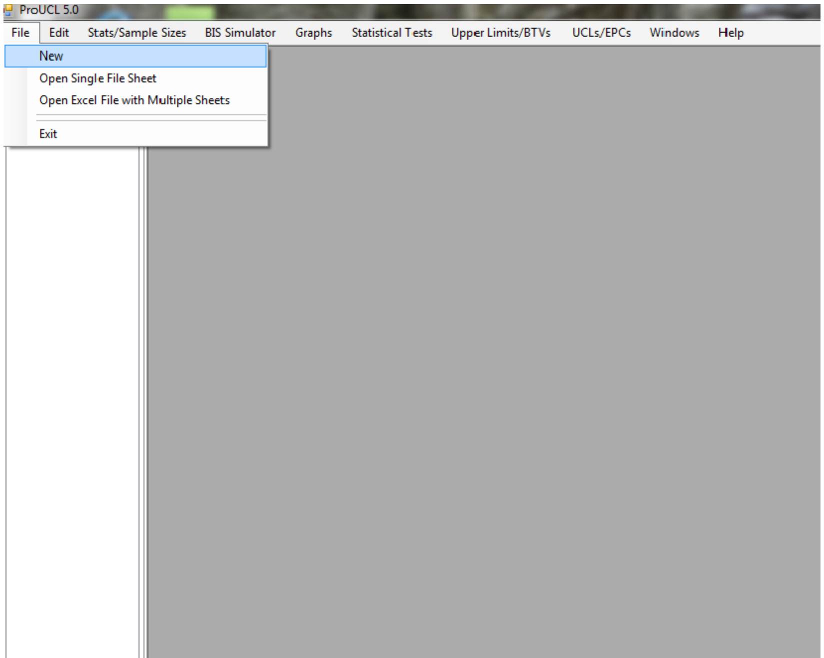
Step 2

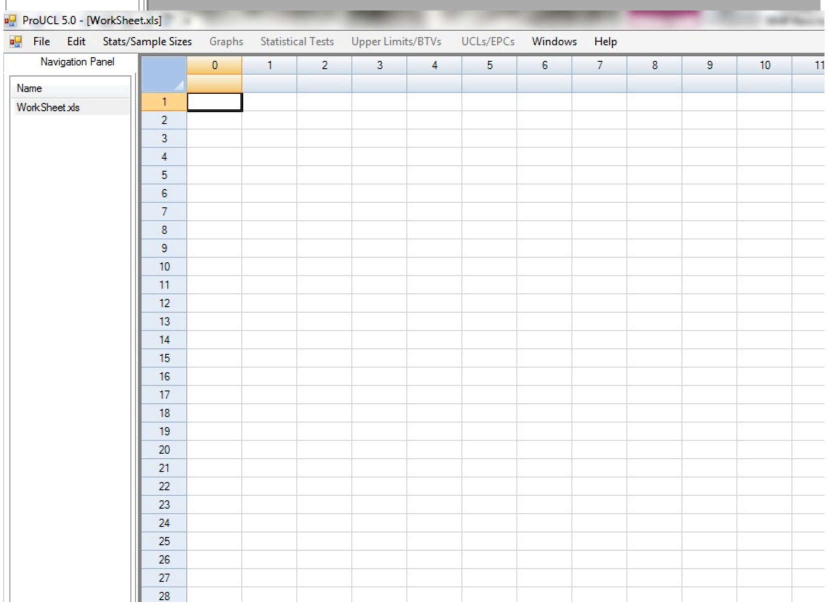
- Determine the percentage of cPAH nondetects by dividing the number of nondetects in each sample by the total number of cPAHs sampled and then multiplying by 100. For example, if 17 cPAHs were analyzed and results indicated 10 nondetects, you would perform the following calculation to determine the percentage of nondetects: 10/17*100 = 59% nondetects.
    1. **If you have 80% or less nondetects, proceed to Step 3**.
    2. **If you have greater than 80% nondetects, proceed to Step 4**.

Step 3 - 80% or Less Nondetects

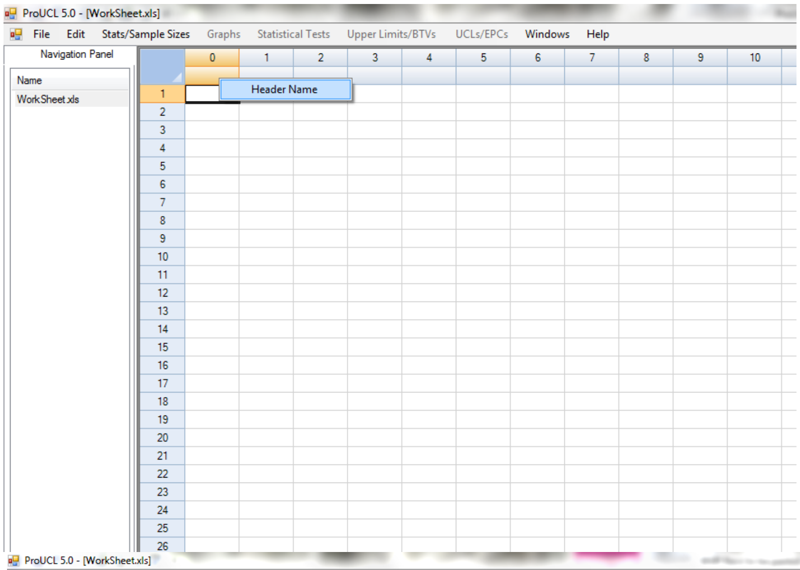
- Use the "Summary of Stormwater Pond Sediment Testing Results" spreadsheet to calculate the BaP equivalent concentration for each of the cPAHs analyzed. The spreadsheet is available on MPCA's Coal tar-based sealants web page at [Coal tar-based sealants | Minnesota Pollution Control Agency (state.mn.us)](). Scroll down to the "Sediment removal guidance" heading.
    1. The spreadsheet will open to the "BaP equiv. calculation" tab.
    2. Under the "Carcinogenic PAH/B[a]P Equivalents Section, enter the site data (concentration) for any detected cPAHs in the "Site Conc." columns (E, G, I), for each core location (sample). If the data you received from the lab is under the laboratory reporting limit but greater than the method detection limit (J flagged or estimated values), enter the estimated value into the spreadsheet treating it like it is a detected concentration. Enter the reporting limit or the method detection limit for all nondetect cPAHs.

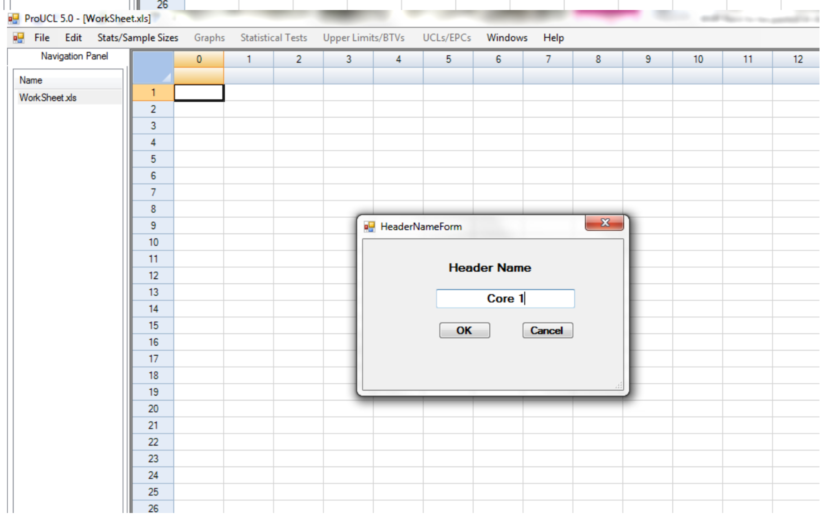
       Note: The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and can provide an estimate of the detected concentration. It does not provide information about compounds reported as not detected. There is a possibility of false negatives for compounds that are not detected.
    3. B[a]P equivalent concentrations will automatically calculate and be displayed in the "BaP Equiv. Conc." columns (F, H, J). The spreadsheet automatically multiples the "Potency Equiv. Factor (PEF)" Column (C) by the "Site Conc." (E, G, I).
    4. The "BaP Equiv. Conc." values (F, H, J) are the values that need to be used to calculate the B[a]P equivalent concentration using Kaplan Meier statistics.
- Use EPA's ProUCL software to calculate the Kaplan Meier mean (KM Mean in ProUCL) B[a]P equivalent concentration.
    1. EPA's ProUCL software is available to download for free at: https://www.epa.gov/land-research/proucl-software.
    2. In ProUCL, open up a new worksheet by choosing "File", then "New".



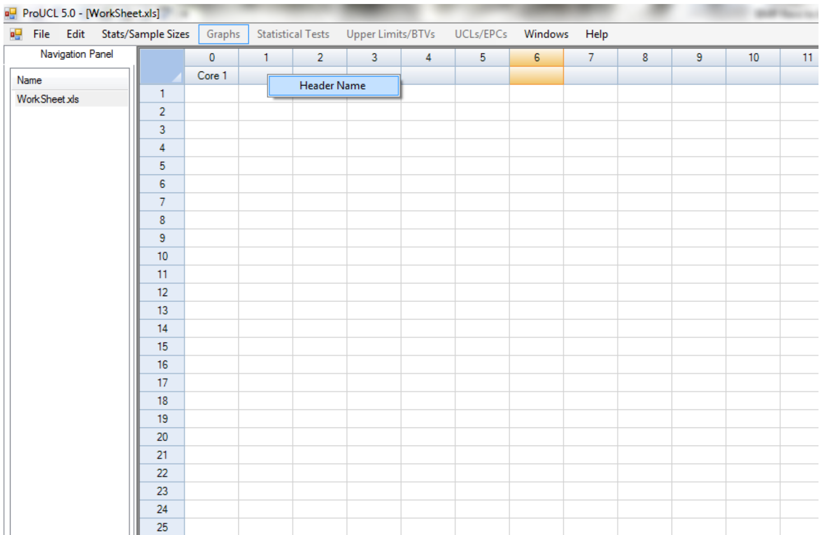


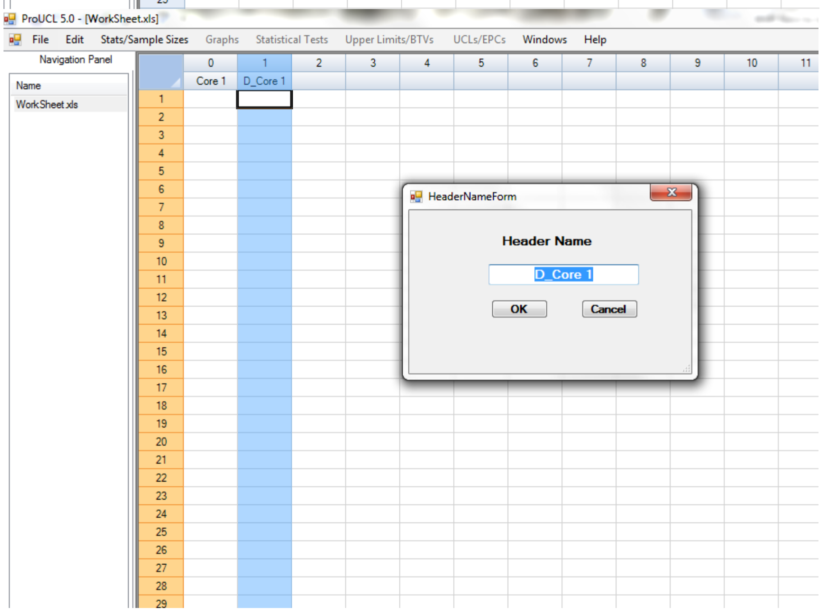
3. Name the first column to identify your core location or sample (ex. “Core 1” or “Sample 1”) by clicking on the header and choosing “Header Name”. The “HeaderNameForm” window will open. Enter the title of that column and click “OK”.



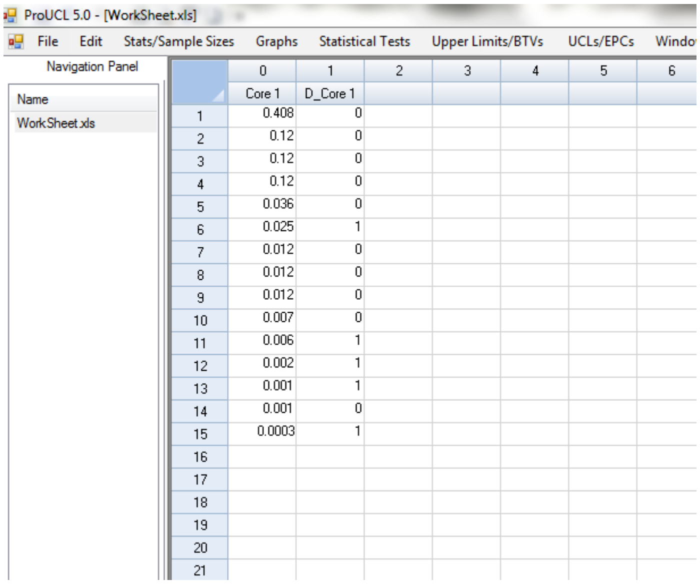


4. Name the second column with a "D_" in front of the name you gave your first column (ex. "D Core 1" or "D_Sample 1") by clicking on the header and choosing "Header Name". The "HeaderNameForm" window will open. Enter the title of that column and click "OK".

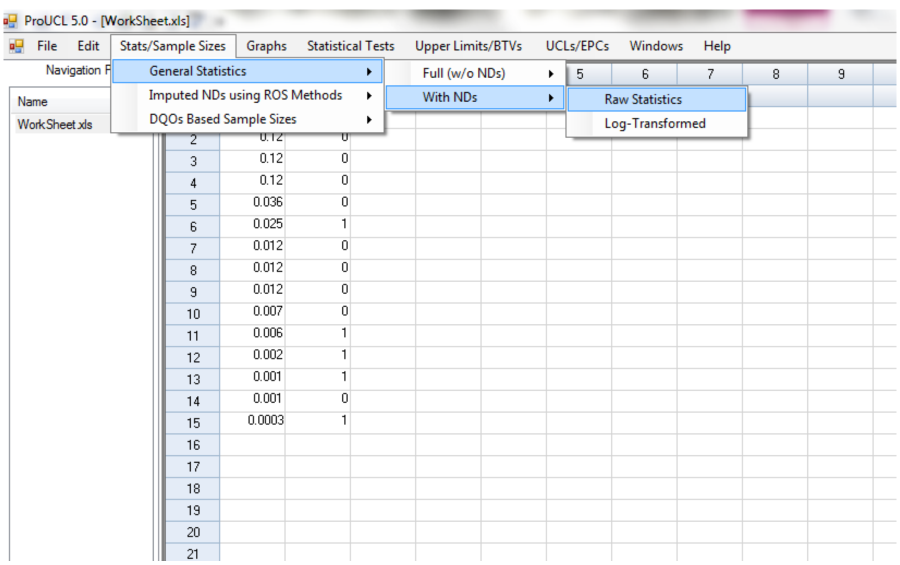


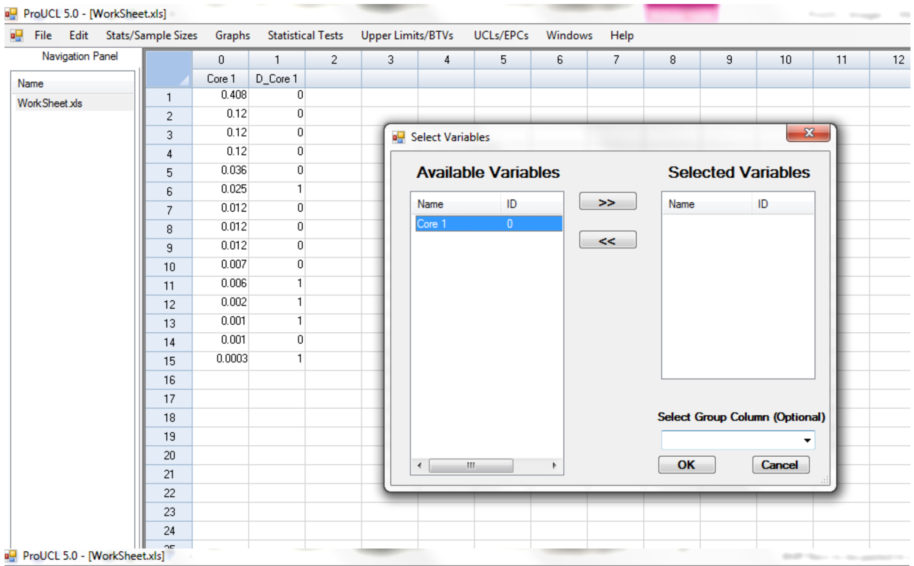


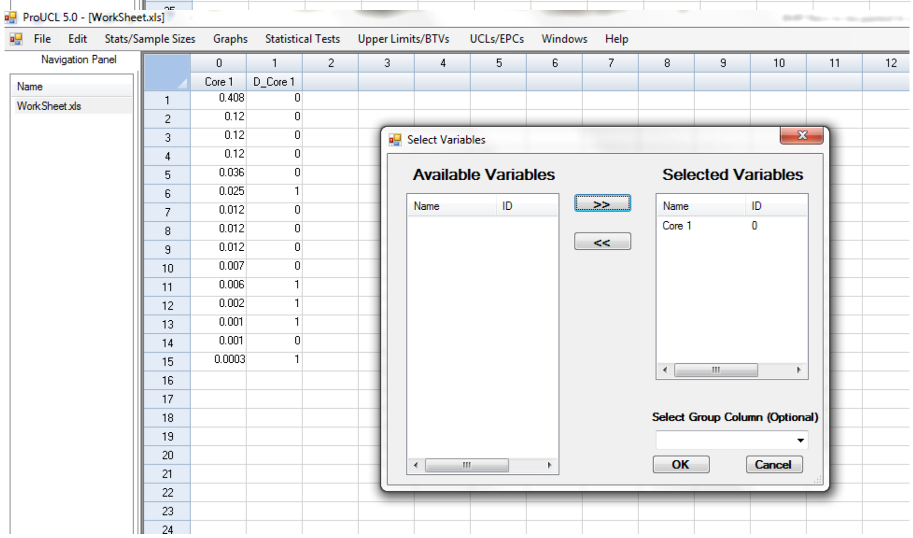
5. Enter the cPAH data from the "Summary of Stormwater Pond Sediment Testing Results" spreadsheet, "BaP Equiv. Conc." Column for your specific core or sample (F, H, I) into the first column (ex. "Core 1" column). In the second column, enter a "0" if that sample (concentration) is a nondetect (based on a reporting limit or detection limit rather than an actual sample concentration) and a "1" if it is a detected concentration. There is no need to conduct any additional sorting of the data ProUCL automatically does this. It is also not necessary to correct for Effron's bias since this is automatically accomplished by ProUCL.



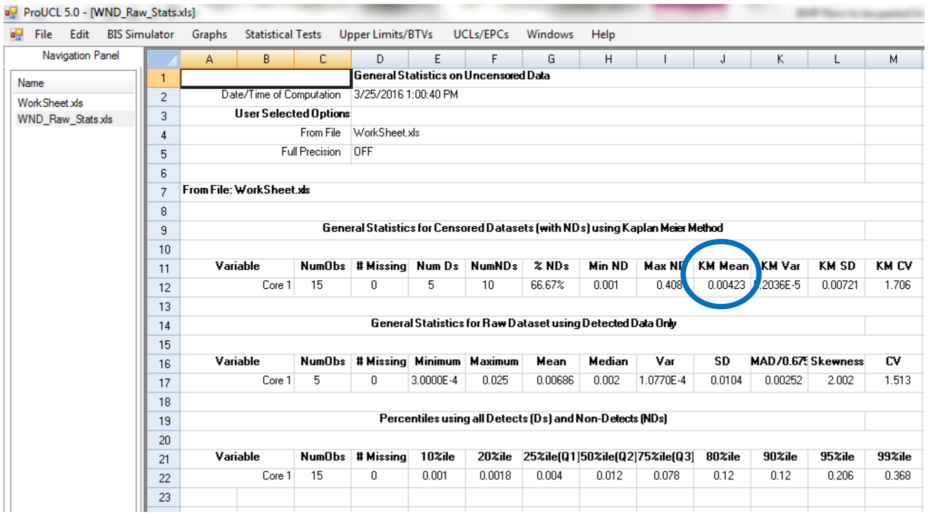
6. Repeat this procedure for each additional core (sample) listed in the “Summary of Stormwater Pond Sediment Testing Results” spreadsheet using additional columns across the spreadsheet (ex. Core 2 or sample 2 would be entered into columns 2 and 3 in the ProUCL spreadsheet).
7. Under “Stats/Sample Sizes”, chose “General Statistics”, “With NDs”, “Raw Statistics”. The “Select Variables” window will open. Click the “>>” button to choose the data you want to use to calculate the “General Statistics”. You can choose all of your cores (samples) at the same time. Click “OK” to run the calculation.







8. ProUCL will calculate "General Statistics" including the Kaplan Meier mean, which is the value you will use to compare to the SRVs (see "KM Mean" in the blue circle below).



9. Multiply the “KM Mean” from ProUCL (value in blue circle above) by the number of cPAHs that were analyzed for and included in this calculation. Enter this value into the “Summary of Stormwater Pond Sediment Testing Results” spreadsheet, “Total B[a]P equivalent – Kaplan Meier” (row 40) under the appropriate core number (sample). For example: If 15 cPAHs were analyzed for, the calculation would be 15 * 0.00423 = 0.0635 mg/kg.
10. Compare each samples “Total B[a]P equivalents – Kaplan Meier” concentration column (row 40) to the Residential and Industrial SRVs listed for B[a]P (columns C, D) for each core location (sample).

    NOTE: If the laboratory reports the 3 fluoranthenes (benzo[b]fluoranthene, benzo[j]fluoranthene and benzo[k]fluoranthene) as total fluoranthenes count this as 1 cPAH. If the laboratory reports two of the fluoranthenes (benzo[b]fluoranthene and benzo[j]fluoranthene) as benzo[b,j]fluoranthene, count this as 1 cPAH.

Step 4 – Greater than 80% Nondetects

- When a dataset has greater than 80% nondetects, Kaplan Meier is no better than stating the B[a]P equivalent concentration is somewhere between the B[a]P equivalent concentration calculated when replacing the nondetects with the full reporting limit and when replacing the nondetects with zeros. Use the “Summary of Stormwater Pond Sediment Testing Results” spreadsheet to calculate the potency equivalent factor (PEF) for each of the cPAHs analyzed. The spreadsheet is available on MPCA’s Coal tar-based sealants web page at [Coal tar-based sealants | Minnesota Pollution Control Agency (state.mn.us)](). Scroll down to the “Sediment removal guidance” heading.

    1. Determine if appropriate reporting limits have been used by comparing the reporting limits used for your samples (found in the laboratory report) to those listed in the Table B-3 below.

        a. If the reporting limit used by the laboratory for a cPAH is equal to or less than the reporting limit in the table, appropriate reporting limits were used for that cPAH. All cPAHs need to be checked. If all cPAHs have been analyzed using appropriate reporting limits, skip to number 2 below to calculate total B[a]P equivalents.

b. If any of the cPAHs did not use an appropriate reporting limit, you cannot calculate B[a]P equivalents using the instructions in number 2 below. In this case, you will need to either re-analyze your samples for the cPAHs that did not have appropriate reporting limits or obtain new samples. The laboratory will be able to help you decide which one makes sense in your case.

   i. If the laboratory is able to re-run the sample and obtain a lower reporting limit, equal to or less than that in Table 1, it might be beneficial to run your sample again for that cPAH.

   ii. If the laboratory had to dilute your sample resulting in an increase in the reporting limit for a cPAH, you will probably need to obtain new samples.

2. To calculate B[a]P equivalents follow the steps below.

   a. In the “Summary of Stormwater Pond Sediment Testing Results”, under the “Site Conc.” column, enter the site data (concentration) for any detected cPAHs in the “Site Conc.” columns (E, G, I), for each core location (sample). If the data you received from the lab is under the laboratory reporting limit but greater than the method detection limit (J flagged or estimated value), enter the estimated value into the spreadsheet treating it like it as a detected concentration. Enter ½ the reporting limit for all nondetect cPAHs.

   b. The B[a]P equivalent concentration will automatically calculate in the “BaP Equiv. Conc.” column. The spreadsheet automatically multiples the “Potency Equiv. Factor (PEF)” column (C) by the “Site Conc.” column (E, G, I) and enters it into the “BaP Equiv. Conc.” Column (F, H, J).

   c. After all of the site concentrations (“Site Conc.”) have been entered, the total B[a]P equivalent concentration is displayed under the “Total BaP Equivalents”, row 39, under the “BaP Equiv. Conc.” columns (F, H, J) for each core location (sample). The spreadsheet automatically sums all of the individual cPAH “BaP Equiv. Conc.” values and enters it into the “Total BaP Equivalents” cell under each core location (sample).

   d. Compare each samples “Total B[a]P equivalents” concentration column (row 39) to the Residential and Industrial SRVs listed for B[a]P (columns C, D) for each core location (sample).

Figure B-1. Calculating B[a]P Equivalents Flowchart

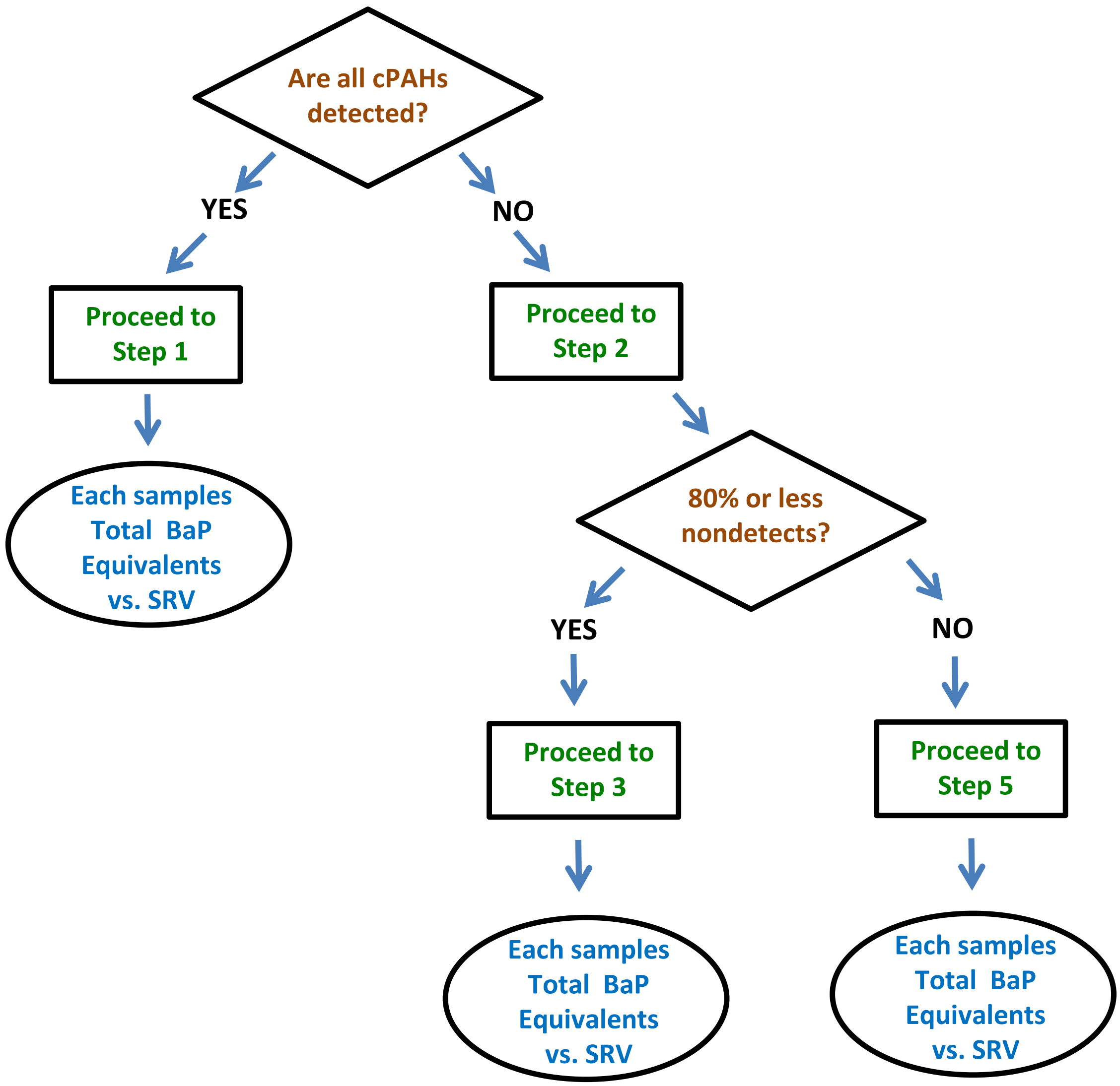


Table B-3. cPAH

Reporting Limits

Carcinogenic PAH (cPAH)	Potency Equivalent Factor (PEF)	Appropriate Maximum Reporting Limit * mg/kg
Benz[a]anthracene	0.1	0.01
Benzo[b]fluoranthene	0.1	0.03
Benzo[j]fluoranthene	0.1	0.03
Benzo[k]fluoranthene	0.1	0.03
Benzo[a]pyrene	1	0.01
Chrysene	0.01	0.01
Dibenz[a,h]acridine	0.1	0.01
Dibenz[a,h]anthracene	0.56	0.01
7H-Dibenzo[c,g]carbazole	1	0.01
Dibenzo[a,e]pyrene	1	0.01
Dibenzo[a,h]pyrene	10	0.01
Dibenzo[a,i]pyrene	10	0.01
Dibenzo[a,l]pyrene	10	0.01
7,12-Dimethylbenzanthracene	34	0.01
Indeno[1,2,3,-c,d]pyrene	0.1	0.01
3-Methylcholanthrene	3	0.01
5-Methylchrysene	1	0.01

* **Laboratory reporting limits listed will need to be corrected for dry weight.**

References

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Cal/EPA. 2009. Technical support document for cancer potency factors: Methodologies for derivation, listing of available values, and adjustments to allow for early life stage exposures. Appendix B. Chemical-specific summaries of the information used to derive unit risk and cancer potency values. Office of Environmental Health Hazard Assessment, Oakland, CA. (https://oehha.ca.gov/air/crnr/technical-support-document-cancer-potency-factors-2009).

Helsel, D.R. 2010. Summing nondetects: Incorporating low-level contaminants in risk assessment. Integr. Environ. Assess. Manage. 6:361-366. (article is freely available at: http://onlinelibrary.wiley.com/doi/10.1002/ieam.31/full).

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