Quality Assurance Project Plan

Assessment of Flame Retardants in Gymnasium Foam and Dust Before and After Product Replacement

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[1] https://apps.ecology.wa.gov/eim/search/default.aspx

Quality Assurance Project Plan

Assessment of Flame Retardants in Gymnasium Foam and Dust Before and After Product Replacement

by Amy Salamone
December 2024

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Signatures are not available on the Internet version.
All staff are from the Washington State Department of Ecology
HWTR: Hazardous Waste and Toxics Reduction Program
ERO: Eastern Regional Office
EAP: Environmental Assessment Program
SWC: Statewide Coordination Section
MEL: Manchester Environmental Laboratory

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2.0 Abstract

Recreational gymnastic facilities have many foam products like floor mats, landing pads, pit cubes, and other padded equipment that often contain flame retardants to slow the spread of fire. Flame retardant exposure is associated with harmful health effects like cancer and endocrine disruption. These recreational gymnastic facilities are typically marketed toward children, with things like gymnastics training, trampoline, bouncy house, circus, and playdate facilities. Children using the foam products and people in the facility may be at risk for exposure to flame retardants released during equipment use and normal product breakdown.

One method to address the exposure hazard to harmful flame retardants is to remove the source. Washington State Department of Ecology's Product Replacement Flame Retardant Foam Disposal Program financially supports replacing foam pit cubes containing toxic flame retardants with alternative foam pit cubes that do not contain added flame retardants. To assess the effectiveness of this replacement program, Ecology will conduct a study at two participating gymnastic facilities to assess flame retardants in the foam pit cubes currently in use and the replacement alternative foam pit cubes. Pit-adjacent indoor floor dust samples will also be collected and tested for the same flame retardants before and after foam replacement to gather information on changes in flame retardant concentrations due to replacement efforts.

3.0 Background

3.1 Introduction

Removing toxic chemicals from consumer products before they cause personal or environmental harm is one of the most effective ways to help protect Washington's public health, environment, and economy. Ecology's Product Replacement Program (PRP), in collaboration with local government partners, provides financial incentives to Washington businesses to remove or replace some of the worst toxic chemicals through product replacement, disposal programs, and best management practices. Ecology's Environmental Assessment Program (EAP) conducts scientific studies to assess the presence of toxic chemicals in products and to monitor the release and persistence of toxic chemicals in the environment.

PRP's Flame Retardant Foam Disposal Program financially supports replacing foam pit cubes containing toxic and unnecessary flame retardants at recreational gymnastic facilities with flame-retardant-free foam pit cubes.

3.1.1 Problem statement

Flame retardants are chemicals added to materials (e.g., textiles, plastics, foams) and surface finishes and coatings to inhibit combustion or delay the spread of fire after ignition (van der Veen and de Boer 2012). Halogenated flame retardants (HFR) are primarily chlorinated and brominated chemicals that Ecology determined are potentially hazardous to the environment and human health (Ecology 2022). Organophosphate flame retardants (OFR) contain phosphorus. Halogenated and organophosphate flame retardants can cause endocrine and immune system disruption, cancer, and harmful effects on children's growth, development, and neurological function (Lyche et al. 2014; van der Veen and de Boer 2012).

Foam pit cubes are used as padding in recreational gymnastic facilities, and pit cubes that contain flame retardants are a source of those chemicals in the indoor environment. Gymnasts come in frequent contact with recreational foam products, and research suggests gymnasts may have higher exposures to flame retardants than the general population (Carignan et al. 2013; Carignan et al. 2016; Dembsey et al. 2019). Intervention studies have successfully reduced gymnasts' exposure to certain flame retardants by replacing old foam pit cubes with alternative foam pit cubes (La Guardia and Hale 2015; Ceballos et al. 2018; Dembsey et al. 2019).

While foam pit cubes in gymnastics facilities have been the best studied, similar recreational foam products that contain flame retardants likely present the same hazard. Recreational foam products are used in facilities that are typically marketed toward children, including trampoline, bouncy house, circus, and playdate facilities. Flame retardants in foam pit cubes can easily migrate out of the pit and accumulate in indoor dust and on people in contact with the foam (Carignan et al. 2016; Dembsey et al. 2019).

3.2 Study area and surroundings

This study will take place at two recreational gymnasium facilities recruited and approved by the PRP. Both facilities offer gymnastics training classes for children. They are also located in areas of Washington that rank high (level 10) on the Washington Environmental Health Disparities Map version 2.0 (published July 29, 2022), accessed at https://fortress.wa.gov/doh/wtnibl/WTNIBL/Map/EHD. Metropolitan Gymnastics, located in Kent, Washington, has two foam pits that have been approved for this study. Lakewood YMCA, located in Lakewood, Washington, has one foam pit that has been approved for this study.

3.2.1 History of study area

Different flame retardants have been used in recreational gym foam over time. Polybrominated diphenyl ethers (PBDEs) were used in many types of polyurethane foam products from the 1980s until recently. PBDEs include PentaBDE, a mixture used in many foam products until it was banned in 2004 by the U.S. Environmental Protection Agency under Toxic Substances Control Act section 5a (40 CFR 721). The manufacture and import of PBDE-containing products and formulations were phased out between 2004 and 2013 in the United States.

A number of alternative flame retardants have replaced PBDEs in polyurethane foam pit cubes. Several studies conducted after the PBDE phase-out (Carignan et al. 2016; Ceballos et al. 2018; Dembsey et al. 2019) have assessed gymnasium foam and reported the following flame retardants:

- 2-ethylhexyl 2,3,4,5-tetrabromobenzoate (TBB)
- 2-ethylhexyl 2,3,4,5-tetrabromophthalate (TBPH)
- triphenyl phosphate (TPP)
- tris(1,3-dichloro-2-propyl) phosphate (TDCPP)
- tris(1-chloro-2-propyl) phosphate (TCPP)
- tris(2-chloroethyl) phosphate (TCEP)

3.2.2 Summary of previous studies and existing data

Previous studies indicate that people are exposed to flame retardants from foam at gymnasium facilities by skin contact and through ingestion of dust and air (Carignan et al. 2013; La Guardia and Hale 2015). One study of a small group of collegiate gymnasts showed that their flame retardant exposure was disproportionately higher than the general population (Carignan et al. 2013). Another study indicated that concentrations of flame retardants in indoor dust can be higher in gymnastics studios than in homes (Ceballos et al. 2018). Gymnasts and trainers can be exposed to flame retardants when using foam pits, as indicated by urinary biomarkers (Carignan et al. 2016) and hand wipe samples (Dembsey et al. 2019).

Foam pit cubes are an important source of flame retardants in the gymnasium environment. Concentrations of flame retardants in dust and air are substantially higher in and near the foam pit area than in other rooms of the gymnasiums (Carignan et al. 2013; Ceballos et al. 2018). La Guardia and Hale (2015) and Ceballos et al. (2018) found flame retardants in interior window dust of foam pit areas, suggesting that flame retardants released from foam pit cubes accumulate in surface dust.

Previous studies have shown that replacing flame-retardant-containing foam pit cubes with flame-retardant-free foam pit cubes reduces the presence of those flame retardants in the facility. One replacement study measured a decrease in the specific flame retardants found in the old foam pit cubes after removing them. This study also measured an increase in the type of flame retardants present in the new foam pit cubes used as replacements because the new cubes were not completely free of flame retardants (Ceballos et al. 2018). One study measured a fivefold decline in the mass of flame retardants accumulated on gymnasts' hands when training at the foam pit after replacement with flame-retardant-free foam (Dembsey et al. 2019).

Fire safety measures are very important for the overall safety of gymnastic facilities. A previous foam replacement study published by Dembsey et al. (2019) also conducted a flammability assessment and facilitated a fire inspection at their partner gymnasium. They found that both pit cubes with and without added flame retardants resisted a smolder ignition source but produced severe fires when exposed to a small flame ignition source. Dembsey et al. (2019) suggested that an existing sprinkler system adequate to control a gymnasium fire would likely also offer control of a fire involving flame-retardant-free foam since foam pit cubes with and without flame retardants had similar heat release rates when burning.

3.2.3 Parameters of interest and potential sources

Table 1 lists the flame retardants to be analyzed for this study.

Table 1: Flame retardant analytes to be assessed.

Flame Retardant Chemical	Abbreviation	CAS RN
tris(1,3-dichloro-2-propyl) phosphate	TDCPP	13674-87-8
tris(2-chloroethyl) phosphate	TCEP	115-96-8
tris(2-chloroisopropyl) phosphate	TCPP	13674-84-5
triphenyl phosphate	TPP	115-86-6
2-ethylhexyl-2,3,4,5 tetrabromobenzoate	TBB	183658-27-7
bis(2-ethylhexyl) tetrabromophthalate	TBPH	26040-51-7
2,2',4,4'-tetrabromodiphenyl ether	BDE-047	5436-43-1
2,3',4,4'-tetrabromodiphenyl ether	BDE-066	189084-61-5
2,2',4,4',5-pentabromodiphenyl ether	BDE-099	60348-60-9
2,2',4,4',6-pentabromodiphenyl ether	BDE-100	189084-64-8
2,2',4,4',5,5'-hexabromodiphenyl ether	BDE-153	68631-49-2
2,2',4,4',5,6'-hexabromodiphenyl ether	BDE-154	207122-15-4

CAS RN = Chemical Abstracts Service Registry Number.

3.2.4 Regulatory criteria or standards

This study does not collect data to perform a risk assessment or to determine compliance with regulatory standards.

Washington State has several laws and rules that address flame retardants in consumer products. As of 2008, the PBDE — Flame Retardants Chapter RCW 70A.405 restricted the manufacture and sale of products containing PBDE flame retardants in Washington. In 2017, Washington State's Children's Safe Products Act (CSPA) established limits on five flame retardant chemicals in children's products manufactured and sold in Washington (Chapter RCW 70A.430).

As of 2023, the Safer Products for Washington Act (RCW 70A.350) is the first state regulation of flame retardants in recreational polyurethane foam. The implementation program for the law identified two groups of flame retardants as priority chemicals: 1) the chemical class of HFRs and 2) five OFRs previously identified in CSPA (Chapter 70A.430 RCW). Ecology identified specific priority recreational polyurethane foam products, including foam pit cubes, since safer alternatives exist (Ecology 2022). The adopted rule, Chapter 173-337 WAC, specified restrictions and reporting requirements for potentially added flame retardants in certain recreational polyurethane foam products. The restrictions outlined in WAC Chapter 173-337 take effect on January 1, 2025.

Flammability standards that may apply to multiple types of recreational foam products are described in Ecology's 2022 Regulatory Determinations Report to the Legislature (Ecology 2022). There is no organizational oversight for product safety or flammability standards for uncovered recreational foam, like foam pit cubes. There are also no specific flammability standards in the building codes of Washington State for uncovered foam pit cubes used in indoor recreation facilities.

4.0 Project Description

This study will assess levels of flame retardants (see Table 1) in foam pit cubes and indoor floor dust before and after site cleaning and replacement at two gymnastic facilities in Washington State.

4.1 Project goals

This study is designed to evaluate the effectiveness of product replacement activities by assessing selected flame retardants in foam pit cubes currently in use and in alternative foam pit cubes chosen as the replacement.

4.2 Project objectives

Study goals will be met through the following objectives:

- Collect representative foam pit cubes currently in use, alternative foam pit cubes selected as the replacement, and pit-adjacent indoor floor dust before and after cleaning and replacement activities.
- Assess the levels of flame retardants in composite samples of foam pit cubes and composite samples of indoor floor dust.
- Evaluate the effectiveness of reducing the presence of flame retardants by comparing the levels of flame retardants in foam pit cubes currently in use to levels in alternative foam pit cubes selected as the replacement.
- Gather information on changes in flame retardant concentrations by comparing the levels of flame retardants in pit-adjacent indoor floor dust before and after pit cleaning and pit cube replacement.

4.3 Information needed and sources

This study will require multiple coordinated access arrangements at each participating gymnastic facility contracted by PRP. Descriptions of cleaning methods used by the janitorial vendor should be provided to the PRP product replacement lead during the contract agreement process. Cleaning method details include cleaning equipment, cleaning chemicals or detergents, and waste disposal methods. This information will be documented in the final report.

4.4 Tasks required

The following tasks, assigned to the project manager, are required for this study:

- Review previous studies that have assessed flame retardants in recreational gymnasium foam products and indoor dust.
- Coordinate with PRP team lead to secure participation contracts with two gymnasium facilities and a contracted janitorial service.

- Organize and prepare for field collections, including scheduling and coordinating with Ecology's Manchester Environmental Laboratory (MEL), the PRP product replacement lead, and the project assistant.
- Submit the pre-sampling notification form to MEL before submission of samples.
- Collect samples of foam pit cubes of up to 8 colors from each foam pit currently in use at each gymnasium facility to equal a maximum of 24 composited samples.
- Collect samples of replacement foam pit cubes of up to 3 colors from each gymnasium facility to equal a maximum of 9 composited samples.
- Collect pit-adjacent indoor floor dust samples before and after pit cleaning and pit cube replacement to equal a maximum of 12 samples.
- Document facility photos and details in the Product Testing Data Base (PTDB) as outlined in 7.2.1.
- Document collection information, product details, and product photos in the PTDB.
- Submit samples for flame retardant analysis at MEL.
- Perform data verification, review data report, and document data in the PTDB and Environmental Information Management System (EIM).
- Perform a QA review of product and lab analysis data in the PTDB and EIM.
- Analyze study data and write a report for publication by Ecology.
- Make laboratory data and product information from this study available on Ecology's PTDB website and EIM.

The following tasks, assigned to PRP's product replacement lead, are required for this study:

- Oversee contracts for study participants at two gymnasium facilities and a contracted vendor for site cleaning.
- Organize and schedule site cleaning of each facility by the contracted janitorial vendor.
- Organize and schedule installation of new, replacement foam pit cubes.

The following tasks, with oversight assigned to MEL's Lab Director, are required for this study:

- Perform flame retardant analysis for up to 33 foam samples and 14 dust samples, as detailed in Section 9.
- Perform internal data verification and submit a data report to the project manager as detailed in Section 11.2.

4.5 Systematic planning process

This QAPP addresses comprehensive systematic planning for this study.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 2 shows the responsibilities of those involved in this project.

Table 2. Organization of project staff and responsibilities.

Staff[1]	Title	Responsibilities
Sean Smith Product Replacement Program, HWTR Phone: 425-324-0328	Client/Product Replacement Program Coordinator	Clarifies the scope, informational needs, and budget of the project. Reviews draft QAPP and approves final QAPP. Provides gymnasium site locations, coordinates access/entry to each participating site, and facilitates cleaning and product replacement along the scheduled timeline.
Amy Salamone Product Testing Unit SCS, EAP Phone: 564-669-1760	Project Manager/ Principal Investigator	Clarifies project scope and design. Writes the QAPP and approves the final QAPP. Leads product and environmental sampling and submission of samples to the laboratory. Leads QA review of lab data, analyzes and interprets data, and enters data into PTDB and EIM along the scheduled timeline. Writes the draft and final report.
Jenna Rushing Product Testing Unit SCS, EAP Phone: 360-407-6492	Project Assistant/ Sample Preparation Lead	Reviews the final QAPP. Leads sample processing and product and component data entry into PTDB. Leads QA review of product data. Assists in QA review of lab data in the PTDB and EIM along the scheduled timeline.
Sara Sekerak Product Testing Unit SCS, EAP Phone: 360-480-9501	Unit Supervisor for the Project Manager	Reviews project scope and budget. Reviews draft QAPP and approves final QAPP. Oversees project progress and reviews draft and approves final report.
Jessica Archer SCS, EAP Phone: 360-407-6698	Section Manager for the Project Manager	Reviews project scope and budget. Approves final QAPP.
Elaine Snouwaert Eastern Regional Office, HWTR Phone: 509-385-5169	Supervisor for the Client	Reviews project scope and budget. Approves the final QAPP.
Rob Waldrop MEL, EAP Phone: 360-871-8801	Director	Approves the final QAPP. Oversees laboratory testing and data validation along the scheduled timeline.
Joan Protasio MEL, EAP Phone: 360-871-8824	Organics Unit Supervisor	Oversees laboratory testing and data package reporting along the scheduled timeline.
Arati Kaza EAP Phone: 360-407-6964	Ecology Quality Assurance Officer	Approves the draft QAPP and final QAPP.

EAP = Environmental Assessment Program
HWTR = Hazardous Waste and Toxics Reduction Program
MEL = Manchester Environmental Laboratory
PTDB = Product Testing Database
QA = Quality assurance
QAPP = Quality Assurance Project Plan
SCS = Statewide Coordination Section
[1] All staff are from the Washington State Department of Ecology

5.2 Special training and certifications

Ecology field staff will follow the requirements in EAP's Safety Manual for all aspects of fieldwork. Staff conducting fieldwork will file an EAP Field Plan for all field events. While conducting fieldwork that may generate nuisance levels of dust, staff may voluntarily wear an N95 mask. Respiratory protection is not required. Ecology staff who perform product collection and processing must follow standard operating procedure (SOP) PTP001 *Procedure for Product Collection and Sample Processing* (Wiseman 2023). Staff who enter product data or perform data QA must follow SOP PTP002 *Data Entry and Data Entry Quality Assurance* (Wiseman 2022a). Staff who enter environmental data or perform data QA must follow Ecology's EIM User's Manual for Ecology Staff version 4.3.

5.3 Organization chart

See Table 2.

5.4 Proposed project schedule

Tables 3 – 5 list key activities, due dates, and lead staff for this project.

Table 3. Schedule for completing sample collection and lab testing.

Task	Due date	Lead staff
Sample collection complete	January 24, 2025	Amy Salamone
Samples submitted to lab	January 31, 2025	Jenna Rushing
Laboratory analyses complete	March 31, 2025	Joan Protasio

Table 4. Schedule for data entry and data quality assurance (QA) processes.

Task	Due date	Lead staff
Product data entry in PTDB	December 31, 2024	Amy Salamone
Environmental data entry in EIM	April 18, 2025	Jenna Rushing
Lab testing data entry in PTDB	April 18, 2025	Amy Salamone
Data QA in PTDB	April 23, 2025	Jenna Rushing
Data QA in EIM	April 23, 2025	Jenna Rushing

PTDB = Product Testing Database.

Table 5. Schedule for final report.

Task	Due date	Lead staff
Draft to supervisor	May 14, 2025	Amy Salamone
Draft to client & peer reviewer	June 6, 2025	Amy Salamone
Final draft to publications team	June 30, 2025	Amy Salamone
Final report due on web	August 8, 2025	EAP Publications

5.5 Budget and funding

Total estimated costs for this study are presented in Tables 6 and 7. Estimations include costs for sample collection and laboratory testing. The number of quality control (QC) samples is not included in the analysis cost (duplicates, matrix spikes, and matrix spike duplicates). This project is funded through Ecology's EAP Product Testing Program.

Table 6. Project budget and funding.

Item	Cost ($)
Product Collection[1]	500
Laboratory (See Table 7 for details)	25,515
Budget Total	**26,015**

[1] Collection includes equipment and travel for two staff for two collection events per facility to equal up to four events

Table 7. Laboratory budget details.

Parameter	Matrix	Number of Samples[1]	Number of QC Samples[2]	Total Number of Samples	Cost Per Sample ($)	Lab Subtotal ($)
Flame Retardant Analysis[3]	Foam	33	12	45	405	18,225
	Dust	14	4	18	405	7,290
Lab Analysis Total						**25,515**

QC = Quality Control.

[1] Samples include field blanks.

[2] QC samples include sample duplicates, matrix spikes, and matrix spike duplicates.

[3] Analytical testing for flame retardants by EPA 8270E at Ecology's Manchester Environmental Laboratory (MEL).

6.0 Quality Objectives

6.1 Data quality objectives

The data quality objective is to collect representative foam pit cubes currently used at each gymnasium facility and alternative foam pit cubes selected as the replacement to evaluate the effectiveness of product replacement activities. To be representative of dust released by pit foam cubes, pit-adjacent indoor floor dust samples will be collected and tested for the same flame retardants before and after cleaning and replacement to gather information on changes in flame retardant concentrations due to replacement efforts. Analytical laboratory testing for the flame retardants listed in Table 1 will follow standard methods that meet measurement quality objectives (MQO) outlined below.

6.2 Measurement quality objectives

The MQOs for laboratory analyses, expressed in terms of acceptable precision, bias, and sensitivity, are described in this section and summarized in Table 8.

6.2.1 Targets for precision, bias, and sensitivity

Table 8. Measurement quality objectives for laboratory analyses.

Parameter	Matrix	Sample, MS Duplicates (RPD[2])	MS, Surrogate[1] (% Recovery[2])	Field Blank	Method Blank	Requested RL (ppm)
Flame Retardants—TDCPP, TCEP, TCPP, TPP, TBB, TBPH, BDE-047, BDE-066, BDE-099, BDE-100, BDE-153, BDE-154	Foam	≤40%	50%–150%	N/A	<½ RL	10
	Dust	≤40%	50%–150%	<RL	<½ RL	10

MS = matrix spike
N/A = not applicable
RPD = relative percent difference
RL = reporting limit
ppm = parts per million
[1] Surrogate compounds are Triphenyl Phosphate-d15 and Decachlorobiphenyl.
[2] Acceptance limits provided are preferred maximum limits since they are not well established for product matrices.

6.2.1.1 Precision

Precision is a measure of variability among replicate measurements due to random error. Laboratory precision will be assessed through duplicate analysis of one sample per analytical batch, and the MQOs are presented in Table 8.

6.2.1.2 Bias

Bias is the difference between the sample mean and the true value. Bias due to sample contamination will be assessed by analyzing field blanks collected at the beginning of each sampling event by vacuuming sodium sulfate powder, as a surrogate for dust, off clean aluminum foil. Laboratory bias will be assessed by analyzing laboratory control samples (LCS) and matrix spike samples (MS). See Table 8 for MQOs.

6.2.1.3 Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the analyte of interest. Laboratory sensitivity is conveyed through the method reporting limit (MRL). See Table 8 for reporting limits.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Comparability of sampling events within each gymnasium facility will be achieved by implementing standardized procedures for sample collection and sample processing. Comparability of results is met through standardized data assurance processes. The study is not designed to generate comparable data between gymnasium facilities. Established SOPs are listed in section 5.2, and sample collection methods are listed in Section 8.2.

6.2.2.2 Representativeness

Representative samples of foam pit cubes currently in use will be collected by compositing three subsamples of all foam pit cube color types present at each site. The representativeness of composite samples will be met by implementing sample homogenization procedures before lab analysis. Established SOPs are listed in section 5.2, and foam-specific methods are detailed in Section 8.2.

6.2.2.3 Completeness

This study will be considered complete if 95% of the analytical results of the samples meet MQOs in Table 8.

6.3 Acceptance criteria for quality of existing data

Not applicable to this study.

6.4 Model quality objectives

Not applicable to this study.

7.0 Study Design

7.1 Study boundaries

The PRP recruited and approved the two recreational gymnasium facilities where the study will take place. Metropolitan Gymnastics, located in Kent, Washington, has two foam pits that were approved for this study. Lakewood YMCA, located in Lakewood, Washington, has one foam pit that was approved for this study.

7.2 Field data collection

7.2.1 Sampling locations and frequency

Two participating recreational gymnastic facilities in Washington State are the sampling locations for this study.

For the first sampling event at each gymnasium facility:

- Samples of foam pit cubes that are currently in use will be collected.
- Indoor floor dust samples will be collected immediately adjacent to the foam pit.

For the second sampling event at each gymnasium facility:

- Foam pit cube samples will be collected from the replacement foam pit.
- Indoor floor dust samples will be collected immediately adjacent to the foam pit at least four weeks after site cleaning and pit cube replacement.

7.2.2 Field parameters and laboratory analytes to be measured

Table 1 lists the laboratory analytes to be measured; methodology details are in Section 9.

7.3 Modeling and analysis design

Not applicable to this study.

7.4 Assumptions underlying design

The pit cube sampling design assumes that the different foam pit cubes currently in use are not equally distributed in the pit. The sampling design assumes that the composited color types of foam pit cubes contain similar levels of flame retardants. Therefore, results are not intended to infer the total concentration of flame retardants present within a specific area.

Site cleaning is assumed to have removed all the old foam pit cubes and residual dust present at the time of cleaning.

The alternative foam pit cubes selected as the replacement are assumed to be free of any additive flame retardants based on written certification by the manufacturer or documented compliance with CA SB 1019. After replacement, the alternative foam pit cubes are assumed to be the only type of pit cubes present in each pit.

An assumption of floor dust sample collection immediately adjacent to the foam pit is that flame retardants detected have originated, at least partly, from the foam pit cubes in the pit. However, dust particulates are a combination of dust from foam, gymnasts, clothing, other equipment, and the facility's air circulation system. Single point in time indoor dust sample measurements are a snapshot of conditions at only one point in time and do not fully capture the range of conditions that may regularly occur.

7.5 Possible challenges and contingencies

The possible logistical challenges, constraints, and schedule limitations for this study are described below.

7.5.1 Logistical problems

An agreement of participation must be obtained from gymnasium facility owners or representatives before sampling begins. If any gymnasium facility denies participation for any reason, the facility will not be replaced by another. The study will begin with the remaining participating gymnasium facilities.

7.5.2 Practical constraints

This project will take place at two gymnasium facilities in Washington State. Travel from Ecology Headquarters to the gymnasium facilities may be complicated by weather or traffic conditions. Travel for sample events will be planned to minimize risk.

7.5.3 Schedule limitations

This project schedule for field sampling is planned to last from October 2024 to January 2025. Even with thorough planning, schedule limitations may arise in the availability of the project assistant, product replacement lead, janitorial vendor, replacement foam vendor, and gymnasium facility representatives. Every effort will be made to sample at all scheduled events, and if needed, sampling may be rescheduled until it is completed, up until January 24, 2025. If the planned laboratory submission window cannot be met, the schedule for the final report will be delayed.

8.0 Field Procedures

8.1 Invasive species evaluation

Not applicable to this study.

8.2 Measurement and sampling procedures

Photos will be taken of each foam pit upon arrival at the site.

8.2.1 Foam Collection

Field staff collecting foam samples will change into new nitrile gloves between samples. Foam sampling tools used in the field will be decontaminated, as detailed in section 8.4. Foam pit cubes will be processed and composited following EAP SOP PTP001 supplemented with the subsampling method described in this QAPP.

The sampling plan is to collect three foam pit cubes of each color from the foam pits currently used at each facility. Foam pit cubes will be selected based on visual differences in color. Up to 10 colors of foam pit cubes will be collected from each pit. Since foam color may fade with time and use, the least-faded pit cubes will be preferred for sample collection. Representative photos will be taken of all colors of pit cubes used at each facility.

In the field, a sample will be collected from whole pit cubes by cutting out a section of foam at least 6 inches by 6 inches. Samples of three pit cubes of each color will be collected and treated as one sample. The three 6-inch by 6-inch foam samples will be wrapped together in clean aluminum foil, sealed into a plastic bag, labeled, and transported to Ecology Headquarters in a secure cooler.

At Ecology Headquarters, pit cube samples will be hand-processed and reduced using pre-cleaned tools on a clean stainless-steel surface lined with aluminum foil and low-lint wipes. A subsample measuring at least 2 inches by 2 inches will be collected from each sample of composited foam pit cubes. Subsamples will then be further hand-reduced into pieces measuring, at most, 1/8 inch cubed and then combined into one sealed glass jar.

All remaining foam pit cube material will be placed back in its original aluminum foil wrap and sealed plastic bag and stored at ambient temperature in a locked cabinet at Ecology Headquarters for retention until the completion of the study.

8.2.2 Dust Collection

Dust collection tools will be decontaminated, as detailed in section 8.4. Staff collecting dust samples are to change into new nitrile gloves between samples.

Pit-adjacent indoor floor dust samples will be collected from gymnasium floors immediately surrounding the foam pit area (within 2 feet of the perimeter) using a vacuum (Eureka Mighty-Mite model 3670) fitted with a cellulose filter (Whatman 2800-199) secured in the crevice attachment tool as described in Carignan et al. (2013) and La Guardia and Hale (2015). Up to two samples of floor dust will be collected at each event. Field blanks will be collected at the beginning of each sampling event by vacuuming sodium sulfate powder, as a surrogate for dust, off clean aluminum foil.

Each dust sample will be wrapped in clean aluminum foil, placed in sealed glass jars, and transported to Ecology Headquarters in a sealed cooler with ice.

8.3 Containers, preservation methods, holding times

Table 9 presents sample matrices, the minimum weight required, appropriate containers, preservation techniques, and holding times that apply to this study.

Table 9. Sample matrices, containers, preservation, and holding times.

Parameter	Matrix	Minimum Weight Required[1]	Container	Preservative[2]	Holding Time[3]
Flame Retardants—TDCPP, TCEP, TCPP, TPP, TBB, TBPH, BDE-047, BDE-066, BDE-099, BDE-100, BDE-153, BDE-154	foam	0.8 g	4 oz wide mouth clear glass jar with Teflon lined lid	none	1 year
	dust, cellulose filter	0.8 g	4 oz wide mouth clear glass jar with Teflon lined lid	Field: cool to 4°C HQ: freeze to -20°C	1 year frozen

HQ = Headquarters of Ecology in Lacey, Washington

[1] Sample weight includes the amount required to analyze sample duplicates, matrix spikes, and matrix spike duplicates.

[2] Preservation methods for consumer products are not well established (Sekerak 2016).

[3] Holding time is approximate for product samples received at MEL; storage may not be standard at all labs.

8.4 Equipment decontamination

Decontamination procedures will follow protocols in SOP PTP001 *Procedure for Product Collection and Sample Processing* (Wiseman 2023). Product testing staff will clean all sampling tool surfaces with a Liquinox detergent solution followed by a 24% ethanol spray before use. Product testing staff will change into new gloves between collecting and processing samples.

8.5 Sample ID

Upon entry into the PTDB, individual product component identification codes are automatically assigned as outlined in SOP PTP002 *Data Entry and Data Entry Quality Assurance* (Wiseman 2022a). Product IDs convey information about the place of collection, the collection event, product number, and component number (e.g., “G1-1-3-1” means gymnasium 1, collection event 1, product number 3, and component number 1 of the product).

A Pre-Sampling Notification form will be submitted to MEL before the samples are submitted. MEL will generate a seven-digit work order number (WO#; e.g., 1601027) for each sample set(s) for an individual study. During sample processing at Ecology Headquarters (Lacey, WA), the addition of a two-digit suffix to the WO# will result in a laboratory sample ID number (e.g., 1601027-01, 1601027-02) for each sample (Sekerak 2016).

8.6 Chain of custody

Appropriate chain of custody procedures will be followed according to SOP PTP001 *Procedure for Product Collection and Sample Processing* (Wiseman 2023). Samples collected for this study will be kept in secure freezers in Ecology's Headquarters until they are submitted to the laboratory. A detailed chain of custody form will accompany all samples during shipment to the lab.

8.7 Field log requirements

Collection event information will be recorded on EAP's Product Documentation Log and entered into the PTDB as outlined in SOP PTP002 *Data Entry and Data Entry Quality Assurance* (Wiseman 2022a).

8.8 Other activities

9.0 Laboratory Procedures

9.1 Lab procedures table

Lab analysis will follow MEL's accredited SOP, MEL730123 Version 2.2: Flame Retardants and Polybrominated Diphenyl Ethers (PBDEs) in Consumer Products by EPA SW-864 Method 8270E.

Table 10. Measurement methods (laboratory).

Analyte	Sample Matrix	Number of Samples	Expected Range of Results (ppm)	Requested Reporting Limit (ppm)	Analytical Method
Flame Retardants — TDCPP, TCEP, TCPP, TPP, TBB, TBPH, BDE-047, BDE-066, BDE-099, BDE-100, BDE-153, BDE-154	foam	33	<100–25,000	10	EPA 8270E, GC/MS
	dust	12	<10–1,000	10[1]	EPA 8270E, GC/MS

GC/MS = gas chromatography mass spectrometry
ppm = parts per million
[1] The achievable reporting limit will depend on the weight of dust that can be collected at each event.

9.2 Sample preparation method(s)

Laboratory sample extraction will follow EPA Method 3546: Microwave Extraction.

9.3 Special method requirements

The laboratory performing testing for this study must meet the acceptance criteria and MQOs listed in Table 8.

9.4 Laboratories accredited for methods

MEL is currently accredited by Ecology for lab analysis of BDE-047, BDE-066, BDE-099, BDE-100, BDE-153, BDE-154, TDCPP, TCEP, TCPP, TPP, TBB, and TBPH by EPA 8270E following SOP MEL730123 Version 2.2.

10.0 Quality Control Procedures

10.1 Table of field and laboratory quality control

Table 11 presents the sample testing QC procedures for this study. Field QC samples will consist of one dust wipe blank for every sample event, as described in section 7.2.1. Lab QC tests will consist of lab control samples, lab control sample duplicates, sample duplicates, method blanks, matrix spikes, matrix spike duplicates, and method surrogates. Laboratory method QC tests, including the initial calibration curve standards and blanks and continuing calibration verification standards and blanks, will follow analytical SOP MEL730123.

Table 11. Quality control samples, types, and frequency.

Laboratory Method	Dust Sample Blanks	Lab Sample Duplicates	Lab Control Sample & Duplicate	Method Blanks	Matrix Spike & Duplicate	Method Surrogates
EPA 8270E	1 per event[1]	1 per batch[2]	1 set per batch[2]	1 per batch[2]	1 set per batch[2]	each sample

[1] event is described in section 7.2.1.
[2] batch = 20 samples or fewer

10.2 Corrective action processes

Ecology staff will adhere to the appropriate SOPs and study-specific processing and preparation protocols described in this QAPP. MEL staff will document whether lab data meet method QC criteria. As soon as it is recognized, the lab will notify the project manager if substantial departures from method techniques are necessary. Any departures from stated analytical methods will be documented by the laboratory and described in the case narrative. When MQO or QC criteria are not met, or if the integrity of the processing and preparation processes are in question, the project manager will determine if samples should be re-collected, re-analyzed, rejected, or used with appropriate qualification.

11.0 Data Management Procedures

11.1 Data recording and reporting requirements

The foam data for this project will be stored in Ecology's PTDB according to SOP PTP002 *Data Entry and Data Entry Quality Assurance* (Wiseman 2022a), and the dust data in Ecology's EIM according to the EIM User's Manual for Ecology Staff version 4.3. The recorded study data will include collection forms, sample descriptions, product photos, and laboratory testing data. Collection and product metadata of collection date, brand name, manufacturer name, and distributor name, if known or discoverable, will be recorded in the PTDB.

Laboratory data will be received electronically from MEL's Laboratory Information Management System (LIMS) or arrive as an electronic data deliverable (EDD) or comparable package. The project manager will perform a final QA review of all data before they are uploaded into the PTDB and EIM.

11.2 Laboratory data package requirements

Labs performing analyses for this study will deliver a complete level 4 data package in electronic format to the project manager. The lab data will contain all required specific content, along with sample and QC data. Case narratives will be included to discuss any problems encountered with the analyses, corrective action taken, changes to the requested analytical method, and a glossary for data flags and qualifiers. The data package must include all sample data, QA/QC sample data, and chain of custody forms needed to independently verify the results and sample handling procedures.

11.3 Electronic transfer requirements

Laboratory case narratives and data packages will be in PDF format and EDDs, respectively. EDDs will be in a .csv or .xlsx spreadsheet format that meets Ecology's product testing formatting requirements and standard EIM formatting requirements. The project manager may approve an alternative format.

11.4 EIM and PTDB data upload procedures

The product data for this project will be stored in Ecology's PTDB according to SOP PTP002 *Data Entry and Data Entry Quality Assurance* (Wiseman 2022a). The environmental data for this project will be stored in Ecology's EIM according to Ecology's EIM User's Manual for Ecology Staff version 4.3.

11.5 Model information management

Not applicable to this study.

12.0 Audits and Reports

12.1 Field, laboratory, and other audits

Analytical labs must participate in performance and system audits of their routine procedures as prescribed by Ecology's Lab Accreditation Program.

The product testing process conducted at Ecology will be audited at a minimum of one audit per year.

12.2 Responsible personnel

Ecology's QA Officer or their designee will conduct any necessary product testing process audits. The processes can include product acquisition, product documentation and data entry in the PTDB, sample screening, sample processing, chain-of-custody, and adherence to product testing QAPPs and SOPs.

12.3 Frequency and distribution of reports

A final published report summarizing the data and findings will be written when the study is completed. The final report will include, at a minimum:

- An overview of the study.
- Goals and objectives of the study.
- Summary statistics of the laboratory results of the foam and dust samples.
- Discussion of methods, any corrective actions, and the significance of any problems encountered.
- Summary tables and graphs of laboratory data.
- Discussion of laboratory results and data quality.

The final report will be available online at:
https://apps.ecology.wa.gov/publications/UIPages/PublicationList.aspx?IndexTypeName=Topic&NameValue=Product+Testing&DocumentTypeName=Publication

12.4 Responsibility for reports

The project manager is responsible for writing the final report, as stated in Table 2.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

The project manager, or assigned designee, will conduct a final review of product metadata entered into the PTDB. All data will be reviewed by the project manager at several stages during the study according to SOP PTP002 *Data Entry and Data Entry Quality Assurance* (Wiseman 2022a).

13.2 Laboratory data verification

Lab data verification evaluates the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. The project manager will review data packages and data quality reports and conduct a QA review of the data to assess suitability. The project manager, with guidance from Ecology's QA Officer, will be responsible for the final acceptance of lab data. Based on these verification assessments, the data will be either accepted, accepted with qualifications, rejected with re-analysis considered, or rejected without re-analysis considered.

13.3 Validation requirements, if necessary

Lab data validation is an analyte- and sample-specific process that extends the evaluation of data beyond data verification to determine the analytical quality of a specific data set. The equivalent of a stage 2B data validation of data for analyses by EPA 8270E will be performed by MEL's Organics Unit Supervisor. This equivalent stage 2B validation will not result in an official data validation report.

13.4 Model quality assessment

Not applicable to this study.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining if project objectives were met

The project manager will assess the quality and suitability of the data based on case narratives, data packages, the data verification report, and the data validation report. Laboratory QC information will be evaluated to determine if MQOs were met for field and method blanks, laboratory control samples, duplicates, matrix spike samples, and surrogates. Reporting limits will be examined to ensure that the defined reporting limit is met (Sekerak 2016).

If all MQOs and QC criteria are met, the data quality will be considered suitable for meeting study objectives. The study will be considered complete, and objectives met if 95% of the samples meet MQOs and QC criteria. If a sample does not meet MQOs or any QC criteria, the data will have an associated “REJ” in the PTDB. The final report for this study will discuss the data quality findings. Analytical data qualifiers used in the PTDB are described in Table 12.

Table 12. Analytical data qualifiers.

Qualifier Symbol in PTDB	Qualifier Description
U	Analyte was not detected above the method reporting limit.
UJ	Analyte was not detected above the reporting limit. However, the reporting limit is an estimated value.
J	Analyte was positively identified. The reported result is an estimate.
NJ	The analyte was tentatively identified in the sample, but the result value reported is an estimate.
REJ	The sample result was rejected due to serious deficiencies in the ability to analyze the sample, meet quality control criteria, or other technical reasons. The presence or absence of the analyte cannot be verified.

PTDB = Product testing database.

14.2 Treatment of non-detects

Laboratory data will be reported down to the reporting limit, with an associated “U” or “UJ” qualifier for samples with analytes not detected at or above the reporting limit. Method blank detections that are within 5 times the detected analyte concentration will be used to censor sample results. This project will qualify detected analyte concentrations in the samples that are <5 times the detected analyte concentrations in the associated method blank as non-detect due to blank contamination.

14.3 Data analysis and presentation methods

The final report will include a summary of the results of this study. Simple summary statistics and data will be presented in tables and graphs. Example summary statistics may include minimum, maximum, median, and frequencies of detection.

The report will include a link to the study data available on the external database: https://apps.ecology.wa.gov/ptdbreporting/

14.4 Sampling design evaluation

The number and type of samples collected and tested were designed to meet the objectives of this study.

14.5 Documentation of assessment

A documentation of the assessment will be in the final report.

15.0 References

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16.0 Appendix: Acronyms, Abbreviations, and Quality Assurance Glossary

Acronyms and Abbreviations

BDE-047	2,2',4,4'-tetrabromodiphenyl ether
BDE-066	2,3',4,4'-tetrabromodiphenyl ether
BDE-099	2,2',4,4',5-pentabromodiphenyl ether
BDE-100	2,2',4,4',6-pentabromodiphenyl ether
BDE-153	2,2',4,4',5,5'-hexabromodiphenyl ether
BDE-154	2,2',4,4',5,6'-hexabromodiphenyl ether
CAS RN	Chemical Abstracts Service Registry Number
CFR	Code of Federal Regulations
CSPA	Washington's Children's Safe Products Act
e.g.	For example
EAP	Environmental Assessment Program
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
ERO	Eastern Regional Office
et al.	And others
GC/MS	Gas chromatography mass spectrometry
HWTR	Hazardous Waste and Toxics Reduction
i.e.	In other words
LCS	Laboratory control sample
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
MRL	Method Reporting Limit
MS	Matrix spike
OFR	Organophosphate flame retardant
PBDE	Polybrominated diphenyl ether
PRP	Product Replacement Program
PTDB	Product testing database
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
RCW	Revised Code of Washington
RL	Reporting limit
RPD	Relative percent difference
SC	Statewide Coordination
SOP	Standard operating procedure
SWC	Statewide Coordination Section
TBB	2-ethylhexyl 2,3,4,5-tetrabromobenzoate
TBPH	2-ethylhexyl 2,3,4,5-tetrabromophthalate
TCEP	Tris(2-chloroethyl) phosphate

TCPP	Tris(1-chloro-2-propyl) phosphate
TDCPP	Tris(1,3-dichloro-2-propyl) phosphate
TPP	Triphenyl phosphate
WAC	Washington Administrative Code

Units of Measurement

ppm	parts per million (milligrams per kilogram)

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms *precision* and *bias* be used to convey the information associated with the term *accuracy* (USGS, 1998).

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella (Kammin, 2010).

Bias: The difference between the sample mean and the true value. Bias usually describes a systematic difference reproducible over time and is characteristic of both the measurement system and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI) (Kammin, 2010; Ecology, 2004).

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process (USGS, 1998).

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured (Ecology, 2004).

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards but should be referred to by their actual designator, e.g., CRM, LCS (Kammin, 2010; Ecology, 2004).

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator (USEPA, 1997).

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator (USEPA, 1997).

Continuing Calibration Verification Standard (CCV): A quality control (QC) sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run (Kammin, 2010).

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system (Kammin, 2010; Ecology 2004).

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean (Kammin, 2010).

Data integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading (Kammin, 2010).

Data quality indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity (USEPA, 2006).

Data quality objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010).

Data validation: An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability, and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier — data are usable for intended purposes.
- J (or a J variant) — data are estimated, may be usable, may be biased high or low.
- REJ — data are rejected, cannot be used for intended purposes.
  (Kammin, 2010; Ecology, 2004).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set (Ecology, 2004).

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero (Ecology, 2004).

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis (USEPA, 1997).

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport (Ecology, 2004).

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples (Kammin, 2010).

Laboratory Control Sample (LCS): A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples (USEPA, 1997).

Matrix spike: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects (Ecology, 2004).

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness (USEPA, 2006).

Measurement result: A value obtained by performing the procedure described in a method (Ecology, 2004).

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed (EPA, 1997).

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples (Ecology, 2004; Kammin, 2010).

Method Detection Limit (MDL): This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero (Federal Register, October 26, 1984).

Percent Relative Standard Deviation (%RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010).

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all parameters (Kammin, 2010; Ecology, 2004).

Population: The hypothetical set of all possible observations of the type being investigated (Ecology, 2004).

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator (USGS, 1998).

Quality assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data (Kammin, 2010).

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives (Kammin, 2010; Ecology, 2004).

Quality control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data (Ecology, 2004).

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled (USGS, 1998).

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator (USGS, 1998).

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population (USGS, 1998).

Sample (statistical): A finite part or subset of a statistical population (USEPA, 1997).

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit (Ecology, 2004).

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method (USEPA, 1997).

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency (USEPA, 1997).

Split sample: A discrete sample subdivided into portions, usually duplicates (Kammin, 2010).

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity (Kammin, 2010).

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning (USEPA, 2006).

References for QA Glossary

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