DEPARTMENT OF ECOLOGY
State of Washington

Quality Assurance Project Plan

Flame Retardants in Electric and Electronic Casings

July 2021

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Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan (QAPP). The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

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Quality Assurance Project Plan

Flame Retardants in Electric and Electronic Casings

by Ken Nelson

July 2021

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Signatures are not available on the Internet version.
EAP: Environmental Assessment Program
HWTR: Hazardous Waste and Toxics Reduction Program

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2.0 Abstract

During January through June 2021, the Washington State Department of Ecology (Ecology) will conduct a study to evaluate plastic casings of electric and electronic products, from various manufacturers, for the presence of flame retardants. This project is in support of the Safer Products for Washington program which has identified electric and electronic products as one of the priority product categories that contains flame retardants. Since the phase-out of polybrominated diphenyl ethers, studies have shown an increase in replacement flame retardants in house dust and the environment. The high number of electric and electronic products found in the average household could contribute to the concentration of flame retardants detected.

Studies identifying the number of flame retardants analyzed for electric and electronic enclosures in Washington State have been limited. There have been some focused studies by other groups outside of Washington State. During 2017 and 2018, Toxic-Free Future (TFF) conducted separate studies on casings from televisions purchased in Washington. No focused investigations on enclosures have been conducted by Ecology. Previous Ecology studies have either focused on nap mats and children's consumer products, such as chairs, sofas, play tents, and tunnels, or have been broad in product scope.

Ecology will carry out a focused study by purchasing a maximum of 150 residential and office electric and electronic equipment. The equipment will contain plastic device casings that will be screened for bromine, chlorine, antimony, and phosphorus using an X-ray fluorescence analyzer. Based on the screening results, a subset of samples will be selected and analyzed for targeted flame retardant chemicals.

3.0 Background

3.1 Introduction and problem statement

Flame retardant chemicals are frequently added to consumer products, such as in furniture and electronics, to meet flammability standards. A variety of different chemicals, with different properties and structures, act as flame retardants; these chemicals are often combined for improved effectiveness of products. For electric and electronic enclosures, one flammability standard is UL (Underwriters Laboratories) 94, a standard that provides a method for classifying ignition characteristics of plastic materials (Underwriter's Laboratories Inc., 2007).

In 2019, the Washington State Legislature passed a law The Pollution Prevention for Healthy People and Puget Sound Act (Chapter 70A.350 RCW, formerly Chapter 70.365 RCW), which identified five priority chemical classes and set up a path for Ecology to regulate these chemicals in consumer products. Among the priority chemical classes identified in the law were halogenated flame retardants, two alternative non-halogenated flame retardants, and several other flame retardants which have been identified as Chemicals of High Concern to Children (CHCC) as part of the Children's Safe Products Act (CSPA). Exposure to these flame retardants is associated with many health concerns (Ecology, 2020). Flame retardants from consumer products can accumulate in our homes, schools, workplaces; they also can be released into the environment (Ecology, 2020).

The Law required Ecology (in consultation with the Washington State Department of Health) to find priority consumer products that are significant sources, or uses of, the priority chemical classes. In a 2020 report to the Legislature, Ecology identified 11 priority product categories, one of these being electric and electronic enclosures (Ecology, 2020). Electric and electronic products were identified as a priority product based on the presence of flame retardants in the device casings of these products. Ecology determined that electric and electronic equipment with plastic device casings are a significant source of flame retardants (Ecology, 2020).

This product category is broad in scope because the component, the plastic enclosure, serves a similar function across a wide range of electric and electronic products (Ecology, 2020). In the report, many flame retardants were identified in a broad range of products. A summary of some relevant halogenated flame retardants and organophosphate flame retardants that have either been found, or have been reported to be used, in electric and electronic applications include the following:

- 1,2-bis(2,3,4,5,6-pentabromophenyl)ethane (DBDPE),
- 1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPE),
- hexabromocyclododecane (HBCD),
- tetrabromobisphenol-A (TBBPA),
- 2,4,6-tris(2,4,6-tribromophenoxy)-1,3,5-triazine (TTBP-TAZ),
- decabromodiphenyl ether (BDE-209),
- 2,4,6-tribromophenol (2,4,6-TBP),
- resorcinol bis(diphenyl phosphate) (RDP), and
- triphenyl phosphate (TPP).

While the available data support broad use of flame retardants in electric and electronic products, the data lead to some notable data gaps. The number of flame retardant chemicals analyzed, and the range of products for electric and electronic enclosures sold in Washington State, has been limited. To help fill this data gap, Ecology will conduct a study specific to plastic electric and electronic enclosures for the flame retardant chemicals listed above.

3.2 Study area and surroundings

Products will be considered for study assessments if they are sold in any physical location (e.g., discount stores, department stores, supermarkets, and warehouse clubs) within Washington or if they are accessible for purchase online by Washington residents or businesses.

3.2.1 History of study area

As discussed in Section 3.1 and detailed in other sections of this Quality Assurance Project Plan (QAPP).

3.2.2 Summary of previous studies and existing data

Several studies have been conducted on organophosphate flame retardants and halogenated flame retardants in Washington State. These studies are either product testing projects that included electric and electronic products or environmental sampling which included flame retardants that can be used in these products. The following is a list of these studies:

- **Flame Retardants in General Consumer and Children's Products.**
  A total of 163 product components from 125 products (39 of which would be considered electric/electronic products) were analyzed for the compounds of interest identified in this 2012 study (Ecology, 2012). A subsequent addendum (Ecology, 2013) included the analysis of three other compounds to assess levels of additional flame retardant chemicals.
- **PBT (persistent, bioaccumulative, and toxic substance) Chemical Trends Determined from Age-Dated Lake Sediment Cores.**
  In 2014, Ecology conducted a study to assess levels of emerging contaminants in fish tissue collected from 11 waterbodies throughout the state (Mathieu and Wong, 2016).
- **Flame Retardants in Ten Washington State Lakes 2017-2018** - Ecology conducted a study to characterize a broad range of flame retardants in the environment (Mathieu, 2019).
- Several other studies by groups outside of Washington State have screened or tested electric and electronic enclosures. TFF, a nonprofit in Washington State, conducted separate studies in 2017 (Schreder, Peele, & Uding, 2017) and in 2018 (Schreder & Uding, 2018) on casings from televisions purchased in Washington. Common analytes are BDE-209, DBDPE, TTBP-TAZ, TBBPA, and RDP (Ecology, 2020).

Previous flame retardant studies by Ecology, as well as reports from Ecology's previous product testing studies, can be reviewed by searching:
https://apps.ecology.wa.gov/publications/UIPages/SearchPublications.aspx

Laboratory data and product information from Ecology's product testing studies are viewable by searching the online database: http://ecyapeem/PTDBPublicReporting

3.2.3 Parameters of interest and potential sources

This study will assess the concentration of flame retardants (Table 8) in a range of electric and electronic products with plastic casings as a priority chemical-product combination identified by the Safer Products for Washington program. As mentioned previously, this priority chemical-product combination focuses only on the device casing. It does not include inaccessible electronic components, which are the parts of an electronic product that are entirely enclosed within the casing and are not capable of coming out of the product or being accessed during any reasonably foreseeable use or abuse of the product (RCW 70A.350.010(5)).

3.2.4 Regulatory criteria or standards

There are several product laws and rules that address flame retardant chemicals. These include persistent, bioaccumulative, toxic substances (Chapter 173-333 WAC), CSPA (Chapter 70.240 RCW), and CHCC (Chapter 173-334 WAC). The Pollution Prevention for Healthy People and Puget Sound Act (Chapter 70A.350 RCW) also identifies flame retardants. The Safer Products for Washington Program implements RCW 70A.350 and, in July 2020, identified electric and electronic products containing halogenated flame retardant chemicals or specific organophosphate chemical compounds as a priority product category. The focus of this product category is on flame retardant chemicals used in plastic electronic enclosures (Ecology, 2020).

4.0 Project Description

During January–February 2021, Ecology will purchase up to 150 residential and office electric and electronic equipment identified as priority products by the Safer Products for Washington program from several online stores and Washington retailers. The plastic device casings will be screened using an X-ray fluorescence (XRF) analyzer for bromine, chlorine, antimony, and phosphorus. The component samples will be sent to Ecology's Manchester Environmental Laboratory (MEL) and a contract laboratory for the analysis of the flame retardant chemicals listed in Table 8.

4.1 Project goals

The major goals for conducting this project are:

- Assessing the presence of flame retardant chemicals in the enclosures of a wide range of electric and electronic products.
- Providing screening and laboratory data to support the Safer Products for Washington Program (implementation of Chapter 70A.350 RCW).

4.2 Project objectives

The following objectives will be carried out by Ecology's product testing team to meet the project goals:

- During January–February 2021, purchase a wide range of residential and office electric and electronic products (up to 150) with plastic device casings. All equipment will be purchased from Washington retailer locations and/or online websites.
- Screen a large number of samples (internal components will not be screened) for bromine, antimony, chlorine, and phosphorus with the XRF analyzer. The screening data will (1) help the project manager prioritize the sample selection for laboratory analysis and (2) provide useful screening information to the client as results can help inform the presence of either halogenated or organophosphate flame retardants.
- Submit up to 40 samples of plastic casings to the laboratory for analysis of the organophosphate flame retardant chemicals listed in Table 8.
- Submit up to 40 samples of plastic casings to the contract laboratory for analysis of the halogenated flame retardants listed in Table 8.
- Screen a large number of plastic casing samples for any trends in typical polymer resins used with the Fourier Transform Infrared Spectrometry (FTIR) analyzer.

4.3 Information needed and sources

Flame retardant characterization studies, methods, and data from sources such as the U.S. Environmental Protection Agency (EPA), as well as peer-reviewed journal articles, will be reviewed, as applicable for product selection; many of these have been summarized in the Priority Consumer Products Report to the Legislature (Ecology, 2020). Reviews of existing product testing data, supplemented with XRF pre-screening of typical home and office electronics, will also be completed to provide additional information for product selection.

Product research regarding its Underwriters Laboratories (UL) rating, and in particular UL 94 for plastic electronic enclosures, should also be identified if applicable. TCO certified, or other third-party certifications such as offered from the Electronic Product Environmental Assessment Tool (EPEAT), may also be researched.

4.4 Tasks required

To meet study goals, the study will include the following tasks:

- During January–February 2021, purchase up to 150 residential and office electric and electronic equipment from several online stores and Washington retailers. This will cover a broad range of products and will be conducted in several stages (if necessary) as follows:
    - Limit the first purchasing event to up to 50 products.
    - Conduct desktop reconnaissance or investigation during purchasing of any obvious UL 94 ratings. Higher ratings may be used as a consideration for purchasing. The nature of the power source, for example, plugged-in versus battery powered products, and the overall power rating of the product can be factored into purchasing decisions.
    - Separate products from first purchasing event into products components and catalog the components in Ecology's Product Testing Database (PTDB). Make a note of any UL codes, FR (Flame Retardant Chemical) codes, as well as any other plastic codes. Also, identify the component(s) that are part of the external plastic device casings. Other plastic components can be screened as time allows.
    - Screen components with the X-ray fluorescence (XRF) analyzer for bromine, phosphorus, antimony, and chlorine.
    - Use the results from the screening to assist in making decisions for an upcoming purchasing event.
- Submit up to 40 external casing component samples for halogenated flame retardants to MEL for cryomilling first. The halogenated flame retardants analysis will be contracted so will be prioritized for cryomilling prior to submittal to the contract laboratory for analysis.
- Submit up to 40 external casing component samples for organophosphate flame retardants to MEL for cryomilling and analysis.
- Perform internal Quality Assurance (QA) review on analytical data and PTDB entries and resolve any issues.
- Enter flame retardant laboratory results into Ecology's PTDB and transfer preliminary data to client.
- Finalize PTDB data and write a short report,
- Make available laboratory data and product information from this study to the public on Ecology's PTDB website.

4.5 Systematic planning process

This QAPP represents adequate systematic planning for this study.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 1 shows the responsibilities of those who will be involved in this project.

Table 1. Organization of project staff and responsibilities.

Staff[1]	Title	Responsibilities
Saskia van Bergen Reducing Toxic Threats Unit, HWTR Program Phone: 360-407-6609	Client/Peer Reviewer	Reviews project scope. Provides peer review of the QAPP and approves the final QAPP.
Ken Nelson Toxic Studies Unit Statewide Coordination Section (SCS) Phone: 360-407-7601	Project Manager	Writes the QAPP. Coordinates with laboratory; oversees product collection, sample screening, processing, sample prioritization, and transportation of samples to laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into PTDB. Writes the draft and final short report.
Prajwol Tuladhar Toxic Studies Unit, SCS Phone: 360-407-6745	Sampling Prep Lead	Purchases products; Enters purchases and products into the PTDB, conducts QA review of these entries; conducts XRF and FTIR screening of products, processes samples, chain-of-custody, and sends samples to laboratory; enters XRF data into PTDB.
Chrissy Wiseman Toxic Studies Unit, SCS Phone: 360-407-7672	Sampling Prep Lead	Same responsibilities as other sampling prep lead plus, provides internal review of the QAPP and approves the final QAPP.
James Medlen Toxic Studies Unit; SCS Phone: 360-407-6194	Unit Supervisor for the Project Manager	Reviews the project scope and budget. Provides internal review of the QAPP, tracks progress, approves the budget, and approves the final QAPP.
Jessica Archer SCS Phone: 360-407-6997	Section Manager for the Project Manager	Reviews the project scope and budget, approves peer reviewer of draft QAPP, and approves the final QAPP.
Lola Flores Reducing Toxic Threats Unit, HWTR Program Phone: 360-407-6876	Unit Supervisor for Client	Coordinates client project scope. Reviews and approves the final QAPP.
Ken Zarker P2RA Section HWTR Program Phone: 360-407-6724	Section Manager for Client	Reviews the project scope and approves the final QAPP.
Alan Rue MEL Phone: 360-871-8801	Manchester Lab Director	Provides internal review of the QAPP and approves the final QAPP.
Christina Frans MEL Phone: 360-871-8829	Manchester Lab QA Coordinator	Reviews QAPP, coordinates and obtains analytical services with contract laboratory. Validates the contract laboratory's analytical data.
Samuel Iwenofu HWTR Program Phone: 360-407-6346	HWTR Quality Assurance Coordinator	Reviews the draft QAPP.
Arati Kaza Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP, approval to begin work, and the final QAPP.

[1]All staff except the client, client's unit supervisor, and client's section manager are from EAP.
P2RA: Pollution Prevention and Regulatory Assistance

5.2 Special training and certifications

Ecology staff conducting sample processing, data entry, and screenings will be trained according to Ecology's Standard Operating Procedures (SOPs) PTP001, PTP004, and PTP005 listed in Section 8.2 as well as SOP PTP002 referenced in Section 11.1.

Staff will follow and participate in all required Ecology health and safety trainings. Staff will also follow and participate in all required purchasing and contracts trainings as their role in this project requires.

5.3 Organization chart

Not Applicable – See Table 1.

5.4 Proposed project schedule

Tables 2 through 4 list key activities, due dates, and lead staff for this project.

Table 2. Schedule for completing product collection, data entry, laboratory work.

Task	Due date	Lead staff
Product collection, Event 1	January 2021	Chrissy Wiseman Ken Nelson
Product data entry, Event 1	January 2021	Chrissy Wiseman Prajwol Tuladhar
Additional Product collection	February 2021	Chrissy Wiseman Ken Nelson
Additional Product data entry	March 2021	Chrissy Wiseman Prajwol Tuladhar
Product screening complete	March 2021	Chrissy Wiseman Prajwol Tuladhar
Internal data entry QA	March 2021	Chrissy Wiseman Prajwol Tuladhar
Cryomilling for contract lab – up to 40 halogenated flame retardant samples	March 2021	Alan Rue
Halogenated flame retardant samples sent to contract lab	April 2021	Ken Nelson Alan Rue
Cryomilling for MEL – up to 40 organophosphate samples	May 2021	Alan Rue
Laboratory analyses for organophosphate samples – MEL completed	June 2021	Alan Rue
Laboratory analyses for halogenated samples – contract lab completed	June 2021	Alan Rue

Table 3. Schedule for data and study reviews and data transfer to client.

Task	Due date	Lead staff
Contract lab data validation complete	July 2021	Alan Rue
All lab data QA reviewed	July 2021	Ken Nelson
All lab data loaded into PTDB	July 2021	Ken Nelson
PTDB study QA review	July 2021	Ken Nelson
Preliminary screening and analytical data transfer to client	July 2021	Ken Nelson

Table 4. Schedule for final short report.

Task	Due date	Lead staff
Draft to supervisor	August 2021	Ken Nelson
Draft to client/peer reviewer	August 2021	Ken Nelson
Final draft (all reviews done) to publications team	September 2021	Ken Nelson
Final report due on web	December 2021	Publications team

5.5 Budget and funding

Table 5 presents the total estimated costs for this project, $125,570, which includes costs for product collection and the MEL contract fee, in addition to the laboratory budget. Table 6 presents laboratory budget costs for this project, estimated to be $87,630. The number of quality control (QC) tests as part of the laboratory budget are only those tests that are not included in the cost of analysis (duplicates, matrix spikes, and matrix spike duplicates). This project is funded by Ecology's Environmental Assessment Product Testing Program budget.

Table 5. Project budget and funding

Item	Cost ($)
Product Collection (up to 150 - may include product replicates to provide a sufficient amount of sample for lab analysis)	20,000
Laboratory (see Table 6 for details)	87,630
MEL Contract Fee (30%)	17,940
Analysis Total	**125,570**

Table 6. Laboratory budget details

Parameter	Number of Samples	Number of QC Samples$^{\Omega}$	Total Number of Samples	Cost Per Sample ($)	Lab Subtotal ($)
RDP, TPP^{++}	40	6	46	405	18,630
BDE-209, DBDPE, BTBPE, HBCD, TBBPA, TTBP-TAZ, 2,4,6-TBP	40	6	46	1,300	59,800
Cryomilling^{++}	80	0	80	115	9,200
				Lab Analysis Total	**87,630**

$^{\Omega}$Includes duplicates, matrix spikes, and matrix spike duplicates.
$^{++}$It is anticipated that MEL will perform the analysis for RDP and TPP, as well as all the cryomilling.

6.0 Quality Objectives

6.1 Data quality objectives

The main data quality objective (DQO) for this project is to collect a broad range of residential and office electric and electronic equipment available to most in Washington from several online stores and Washington retailers. As well as to provide screening and laboratory data to support the Safer Products for Washington Program (implementation of Chapter 70A.350 RCW). The plastic devices isolated from the equipment will be analyzed to obtain concentration data for select organophosphate and halogenated flame retardants. The XRF and FTIR screening data will meet the QA/QC requirements and instruments' performance limits as outlined in SOPs PTP004 and PTP005 respectively. The laboratory analysis will meet the methods' QA/QC and instruments' performance limits, as well as measurement quality objectives (MQOs) that are described below.

6.2 Measurement quality objectives

6.2.1 Targets for precision, bias, and sensitivity

The MQOs for flame retardant results, expressed in terms of acceptable precision, bias, and sensitivity, are described in this section and summarized in Table 7.

Table 7. Measurement quality objectives for laboratory analyses.

Parameter	LCS, MS and Sample Duplicates (RPD)	LCS (% Recovery)	Matrix Spike (% Recovery)	Surrogate + (% Recovery)	Method Blanks	Target Reporting Limit (ppm)Ω
Triphenyl phosphate (TPP)	≤ 40%	50 – 150%	50 – 150%	50 – 150%*	<LLOQ	100
Resorcinol bis(diphenyl phosphate) (RDP)	≤ 40%	50 – 150%	50 – 150%	50 – 150%*	<LLOQ	1000
Decabromodiphenyl ether (BDE-209)	≤ 40%	50 – 150%	50 – 150%	50 – 150%**	<LLOQ	100
2,4,6-Tris(2,4,6-tribromophenoxy)-1,3,5-triazine (TTBP-TAZ)	≤ 40%	50 – 150%	50 – 150%	50 – 150%**	<LLOQ	100
2,4,6-Tribromophenol (2,4,6-TBP)	≤ 40%	50 – 150%	50 – 150%	50 – 150%**	<LLOQ	100
1,2-Bis(2,3,4,5,6-pentabromophenyl)ethane (DBDPE)	≤ 40%	60 – 140%	60 – 140%	50 – 150%**	<LLOQ	100
1,2-Bis(2,4,6-tribromophenoxy)ethane (BTBPE)	≤ 40%	60 – 140%	60 – 140%	50 – 150%**	<LLOQ	100
Tetrabromobisphenol A (TBBPA)	≤ 40%	60 – 140%	60 – 140%	50 – 150%**	<LLOQ	100
Hexabromocyclododecane (HBCD)	≤ 40%	60 – 140%	60 – 140%	50 – 150%**	<LLOQ	100

LCS = laboratory control sample
MS = matrix spike
RPD = relative percent difference
LLOQ = lower limit of quantitation
ppm = parts per million
+Dilution of labelled compounds may require re-extraction.
*d15-TPP as MEL is anticipated to perform the analysis
**Acceptance limits are not well established for product matrices. The provided limits represent the preferred maximum limits.
ΩIndividual lab reporting limits may vary based upon specific matrix type

6.2.1.1 Precision

Precision is a measure of the variability in the results of measurements due to random error.

Laboratory precision will be assessed through laboratory duplication of product samples. See Table 7 for MQOs.

6.2.1.2 Bias

Bias is the difference between the population mean and the true value. Assessments of laboratory bias will be determined by analysis of laboratory control samples (LCSs), matrix spiked samples, and standard reference materials. See Table 7 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 flame retardant of interest.

Reporting Limits for each analyte are listed in Table 7.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Comparability will be ensured by implementing standardized procedures for sampling and analysis.

Appropriate established methods, procedures, and the SOPs (PTP001, PTP004, and PTP005) listed in Section 8.2 will be followed as applicable by matrix and analyte.

6.2.2.2 Representativeness

Ecology staff will purchase products representative of those available to Washington residents.

6.2.2.3 Completeness

The project manager will consider the study to have achieved completeness if 95% of the laboratory samples are analyzed acceptably.

6.3 Acceptance criteria for quality of existing data

NA

6.4 Model quality objectives

NA

7.0 Study Design

7.1 Study boundaries

Ecology will collect about 150 electric and electronic products containing plastic device casings from a wide range of products from various manufacturers, within the scope of the Safer Products for Washington program for priority products for testing. Product testing staff will collect products either in person or through internet retailers. General reconnaissance will be conducted of available electric and electronic devices in the stores where products are purchased. Knowing available products will be useful for subsequent purchasing events. There will be up to three purchasing events, with the first event being limited to 50 products. If available, manufacture dates, FR codes, plastic codes, and the UL 94 ratings will be manually recorded. Emphasis will be given to products with higher UL 94 ratings, as well as those product categories with less existing data.

All products will have at least one component screened for bromine, chlorine, antimony and phosphorus using the XRF. The components of interest are the parts of the plastic device casings. If possible, photos of the UL 94 or any other UL rating will be recorded and stored in Ecology's Product Testing Database. If marketing information was used to identify the product and it contained UL 94 information, it will be saved.

Product components will be screened for bromine, chlorine, antimony, and phosphorus using the XRF. The objective of the screening method is to evaluate a large number of samples for bromine and phosphorus, and to a lesser extent, chlorine and antimony. Detection of bromine will indicate the potential presence of brominated flame retardants. Detection of phosphorus will indicate the potential presence of organophosphate flame retardants. The screening methodologies, in addition to staggered purchasing events (refer to Section 4.4), will enable the purchasing and sampling funds to be used for those samples more likely to contain flame retardants while also assessing a broad range of electric and electronic products.

Based on the XRF screening results of bromine, and considering the diversity of the products and product lines, a subset of samples will then be selected and analyzed for the halogenated flame retardants BDE-209, TTBP-TAZ, 2,4,6-TBP, DBDPE, BTBPE, TBBPA, and HBCD. Based on the XRF screening results for phosphorous, and the diversity of the products and product lines, another subset of samples will also be selected and analyzed for the organophosphate flame retardants TPP and RDP.

7.2 Field data collection

7.2.1 Sampling locations and frequency

Products will be purchased from retailers and online retailers over several weeks. To maximize efficiency in purchasing, retailers will be mainly from locations in and around the South Sound area of Washington. Purchasing events will occur in other areas of western Washington as time allows. When possible, products purchased and collected in this study will include those that are accessible and/or relevant to diverse ethnic, cultural, and economic groups in Washington. Online and in-store purchases will be planned to minimize purchasing events. Online purchasing may be limited in this study if there are potential delays in shipping.

7.2.2 Field parameters and laboratory analytes to be measured

Table 8 lists the laboratory analytes to be measured by matrix. There are two analyte groups for the flame retardant chemicals (FRs), one for halogenated and one for organophosphates. Some samples may be analyzed by both MEL and the contract laboratory. There are no field parameters to be measured for this study.

Table 8. Laboratory analytes and sample matrices for each analyte.

Analyte Group	Chemical Name	Acronym	CAS* Number	Matrix
Halogenated FR	Decabromodiphenyl ether	BDE-209	1163-19-5	plastic
Halogenated FR	1,2-Bis(2,3,4,5,6-pentabromophenyl)ethane	DBDPE	84852-53-9	plastic
Halogenated FR	1,2-Bis(2,4,6-tribromophenoxy)ethane	BTBPE	37853-59-1	plastic
Halogenated FR	Tetrabromobisphenol A	TBBPA	79-94-7	plastic
Halogenated FR	Hexabromocyclododecane	HBCD	3194-55-6	plastic
Halogenated FR	2,4,6-Tris(2,4,6-tribromophenoxy)-1,3,5-triazine	TTBP-TAZ	25713-60-4	plastic
Halogenated FR	2,4,6-Tribromophenol	2,4,6-TBP	118-79-6	plastic
Organophosphate FR	Triphenyl phosphate	TPP	115-86-6	plastic
Organophosphate FR	Resorcinol bis(diphenyl phosphate)	RDP	57583-54-7	plastic

*Chemical Abstracts Service

7.3 Modeling and analysis design

N/A.

7.4 Assumptions underlying design

Online purchasing of products is available to most people in Washington State, and retail chain stores sell similar products at various locations throughout Washington.

Products with a flammability standard are more likely to contain flame retardant chemicals, especially those with the higher flame resistant standards.

Electronics that have a higher power rating are more likely to have a higher flame retardant content.

7.5 Possible challenges and contingencies

As this study focuses on the device casing and does not include inaccessible electronic components, a given electronic device may yield a limited amount of sample. For example, a game controller may have a minimal amount of plastic material when compared to a vacuum cleaner. Multiple purchasing events are scheduled for this project so products can be deconstructed at the lab in stages. Deconstruction will confirm the actual electronic enclosure and also indicate sample size. Multiple products can then be purchased, if indicated by screening, for compositing.

7.5.1 Logistical problems

A combination of online and in-store purchasing will be used for acquiring products efficiently. The Covid-19 pandemic may have implications on manufacturing, distributing, and accessing products.

7.5.2 Practical constraints

The limited availability of the Ecology credit card and the restrictions of its usage may place additional constraints, considering there could be multiple purchasing events for this study. Approximate dates of purchasing should be forwarded to the appropriate officer or manager, as outlined in the *Product Collection and Sample Processing SOP* PTP001, to minimize inefficient and unproductive outings.

7.5.3 Schedule limitations

Practical constraints regarding product collection are not anticipated to impact the schedule of this study.

8.0 Field Procedures

8.1 Invasive species evaluation

Not applicable.

8.2 Measurement and sampling procedures

The following product testing Standard Operating Procedures (SOPs) will be followed:

- PTP001 *Product Testing Standard Operating Procedure For Product Collection and Sample Processing, Version 2.1* (Wiseman, 2021a).
- PTP004 *Standard Operating Procedure for Thermo Fisher Scientific Niton XL3T GOLDD+ X-ray Fluorescence Analyzer, Version 1.0* (In publication).
- PTP005 *Standard Operating Procedure for Thermo Scientific Nicolet iS5 FTIR Spectrometer, Version 1.1* (In publication).

8.3 Containers, preservation methods, holding times

Table 9 presents sample matrices, sample minimum quantities (not accounting for sample duplicates, matrix spikes, matrix spike duplicates), container specifications, preservation, and approximate holding times. Solids will be reduced in size necessary for cryomilling in pre-cleaned glass jars provided by MEL or the contract laboratory.

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

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
Halogenated FRs	plastic	1 g⁺	4 or 8 oz glass jar	reduced temperature	1 year^Ω
Organophosphate FRs	plastic	0.5 g⁺	4 or 8 oz glass jar	reduced temperature	1 year^Ω

⁺Minimum quantity does not include sample duplicates, matrix spikes, or matrix spike duplicates.
^ΩThis is an approximate holding time for product testing samples received at MEL, storage may not be standard across all labs. Refer to the Product Collection and Sample Processing SOP PTP001 for guidance on retaining samples.

8.4 Equipment decontamination

To obtain reliable and usable data, it is essential that staff employ effective decontamination processes. Decontamination procedures should follow protocols outlined in the *Product Testing SOP for Product Collection and Sample Processing* (SOP PTP001).

8.5 Sample ID

Individual product component identifications (IDs) are auto-generated by the PTDB during product and component login, as described in the *Product Testing Database Standard Operating Procedure for Data Entry and Data Entry Quality Assurance* (SOP PTP002). Product component IDs combine information from store of purchase, purchase event, product, and component of product (e.g., "TG-1-1-2" = Target, purchase event 1, product 1, 2nd component of the product tested).

Submit the Pre-Sampling Notification form prior to the planned submission of samples. 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 HQ (Ecology Headquarters in Lacey), 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, 2016a).

Staff will record sample ID numbers and their corresponding product component IDs on both the sample containers and the Chain-of-custody form. Sample ID numbers are generated the same for both MEL and subcontract analysis.

8.6 Chain of custody

Chain of custody will be maintained for all samples throughout the study. Specific protocols are outlined in the *Product Collection and Sample Processing SOP* PTP001 for storage of products, samples, and shipment of product component samples to the laboratory.

8.7 Field log requirements

Advertisements, photos of product marketing, and other information gathered during study purchasing events will be recorded and uploaded or scanned into the PTDB by study. Specific protocols are outlined in the *Product Collection and Sample Processing SOP* PTP001.

8.8 Other activities

Pre-screening of some existing typical home and office electronic will be conducted. Section 11.1 documents where the data will be stored so it can be referenced in product selection if necessary. The pre-screening XRF results will not be uploaded to the PTDB. The pre-screening XRF data will still be stored in Ecology's Product Testing F Drive, in study-specific folders.

Retention samples may be kept for components that have a notable detection of bromine, chlorine, phosphorus, or antimony even if not sent to the laboratory for testing. Also refer to the *Product Collection and Sample Processing SOP* PTP001 for guidance on retaining samples.

Staff will screen many samples for typical polymer resins, using the FTIR analyzer.

9.0 Laboratory Procedures

9.1 Lab procedures table

MEL is anticipated to conduct all analyses for TPP and RDP. MEL will attempt to obtain the target reporting limits outlined in Table 10. It will be necessary to post a solicitation for the halogenated FRs because MEL cannot conduct analyses for all the halogenated FRs at this time. Also, new methods for TTBP-TAZ and 2,4,6-TBP may have to be developed by the contract lab. All contracts for lab analysis will be managed through MEL.

The contract laboratory is also expected to attempt to obtain the target reporting limits outlined in Table 10. Because some methods are non-standard or newly developed as it relates to consumer products, it may not be possible to report down to these levels for all analytes. The contract lab should have established methods, or will establish methods, in which the instrumentation may differ from what is outlined. Ecology's project manager will decide whether to continue with the analysis.

Table 10. Measurement methods (laboratory).

Analyte	Sample Matrix	Number of Samples	Estimated Arrival Date[∞]	Expected Range of Results (%)	Target Reporting Limit (ppm)	Analytical Method
Triphenyl phosphate (TPP)[++]	plastic	Up to 40	March 2021	<0.01 - 20	100	Modified EPA 8270E[ΩΩ]; GC-MS[Ω]
Resorcinol bis(diphenyl phosphate) (RDP)[++]	plastic	Up to 40	March 2021	<0.01 - 20	1000	Modified EPA 8270E[ΩΩ]; GC-MS[Ω]
Decabromodiphenyl ether (BDE-209)	plastic	Up to 40	March 2021	<0.01 - 25	100	Contract Lab; GC-HRMS[+]
2,4,6-Tris(2,4,6-tribromophenoxy)-1,3,5-triazine (TTBP-TAZ)	plastic	Up to 40	March 2021	<0.01 - 25	100	Contract Lab; GC/ECNI-MS[**] or LC-MSMS[*]
2,4,6-Tribromophenol (2,4,6-TBP)	plastic	Up to 40	March 2021	<0.01 - 25	100	Contract Lab; GC-MS[Ω] or LC-MSMS[*]
1,2-Bis(2,3,4,5,6-pentabromophenyl)ethane (DBDPE)	plastic	Up to 40	March 2021	<0.01 - 25	100	Contract Lab; GC-HRMS[+]
1,2-Bis(2,4,6-tribromophenoxy)ethane (BTBPE)	plastic	Up to 40	March 2021	<0.01 - 25	100	Contract Lab; GC-HRMS[+]
Tetrabromobisphenol A (TBBPA)	plastic	Up to 40	March 2021	<0.01 - 25	100	Contract Lab; LC-MSMS[*]
Hexabromocyclododecane (HBCD)	plastic	Up to 40	March 2021	<0.01 - 25	100	Contract Lab; GC-HRMS[+] or LC-MSMS[*]

[Ω]GC-MS = gas chromatography mass spectrometry
[ΩΩ]EPA = U.S. Environmental Protection Agency
[∞]For cryomilling at MEL
[++]TPP and RDP are being analyzed at MEL
[+]GC-HRMS = gas chromatography high resolution mass spectrometry
[**]GC/ECNI-MS = gas chromatography electron capture negative ionization mass spectrometry
[*]LC-MSMS = liquid chromatography-tandem mass spectrometry

9.2 Sample preparation method(s)

Sample processing and preparation done by HQ staff will follow the procedures outlined in the *Product Collection and Sample Processing SOP*. The screening of product and component samples by XRF and FTIR should follow the procedures outlined in the *XRF and FTIR SOP*s (PTP004 and PTP005, respectively).

MEL will perform the cryomilling on all samples to be sent to the laboratory prior to preparation and analysis following their cryomill SOP (MEL document# 720033).

9.3 Special method requirements

The screening of product and component samples should follow the *XRF SOP for the Thermo Fisher Scientific Niton XL3T GOLDD+ model* (SOP PTP004). This XRF model has the capability to screen products for light elements like phosphorus, and therefore a useful screening tool for the identification of samples that likely contain organophosphate flame retardants, like TPP and RDP.

When samples are cryomilled, no rinsate blanks are required for this study.

The laboratory carrying out the analysis must meet the acceptance criteria in Section 6.2 and must demonstrate the ability to achieve the reporting limits outlined in Section 9.1 of this QAPP. It is preferable if reference standard analyte concentrations are at or near target reporting limit levels.

9.4 Laboratories accredited for methods

A laboratory accreditation waiver will need to be obtained for this project for analysis of any flame retardants in which a laboratory is not accredited. Some of the flame retardant analysis are non-standard methods or newly developed as it pertains to consumer products. MEL and the project manager will work with Ecology's QA officer to obtain a waiver that includes, at a minimum, SOPs and initial demonstration of capability for the analysis.

10.0 Quality Control Procedures

10.1 Table of field and laboratory quality control

Table 11 presents the lab QC procedures for this study. Lab QC tests will consist of method blanks, lab control samples, lab control sample duplicates, sample duplicates, matrix spikes, matrix spike duplicates, and field replicates.

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

Parameter	Product Replicates	Laboratory Control Samples/LCSD	Method Blanks	Sample Duplicates	Matrix Spikes/MSD	Surrogates
Flame Retardant Analysis	Applicable only when collected	1/batch	1/batch	1/batch	1/batch	each sample

LCSD = laboratory control sample duplicates
MSD = matrix spike duplicates
Batch = 20 samples or fewer

10.2 Corrective action processes

The project manager will work closely with the laboratories, appropriate QA representatives(s), and any third-party reviewers conducting data reviews to examine data that fall outside of QC criteria. HQ staff will also adhere to appropriate SOPs and study-specific processing and preparation protocols. The project manager will determine if samples should be re-sampled, re-analyzed, rejected, or used with appropriate qualification when QC criteria are not met or if the integrity of the processing and preparation processes are in question.

11.0 Data Management Procedures

11.1 Data recording and reporting requirements

Product login will follow the Product Testing Program SOP

- PTP002 Product Testing Database Standard Operating Procedure For Data Entry and Data Entry Quality Assurance, Version 2.1 (In publication).

Study data will be stored in Ecology's PTDB. The database stores product descriptions, purchase receipts, photos of products, screening data, laboratory data, and case narratives.

Laboratory data will be transferred electronically from MEL's Laboratory Information Management System (LIMS) into the PTDB or arrive as an electronic data deliverable (EDD) package.

For all data to be loaded into the PTDB, the project manager will perform a QA review of both LIMS-delivered and contract EDDs data. Upon completion of the QA review, the project manager or designated staff will upload the final QA-reviewed data to the internal PTDB (Sekerak, 2016a).

Internally generated screening data

All XRF and FTIR raw data will be initially verified by the analyst for completeness and accuracy (per the applicable SOPs PTP004 and PTP005 respectively), and the data will be made available to the project manager prior to the laboratory analysis sample selection process.

Verified XRF screening results are uploaded to the internal PTDB, are available internally through Lab results searches, and can be exported out into Comma Separated Value (.CSV) files. Raw XRF spectrum/data files are stored in the internal PTDB as .NDT file attachments to uploaded XRF batches. Narratives attached to XRF batches provide a discussion of issues encountered during the XRF screening. The pre-screening XRF results will not be uploaded to the PTDB. The pre-screening XRF data will still be stored in the Product Testing F Drive, in study-specific folders.

The FTIR data are stored in the Product Testing F Drive, in study-specific folders. The FTIR results are not currently stored within the PTDB.

XRF and FTIR data are used for internal preliminary screening processes only and are not searchable on the external PTDB.

All the XRF raw data screening results will be available on request in excel format.

11.2 Laboratory data package requirements

Laboratories performing analyses under this program will provide an electronic deliverables package after completing their work.

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. All sample results and QC data will be included with the package (Sekerak, 2016a).

When data validation is required, study-specific contract laboratory requirements will be discussed more thoroughly in contract documents (e.g., Request for Laboratory Services). If a contract laboratory is required, the contract laboratory will deliver a Tier 4 Level data package to MEL with the complete raw laboratory dataset. For MEL-generated data, case narratives will be sufficient.

11.3 Electronic transfer requirements

Case narratives will be in Adobe Acrobat (.PDF) format, and EDDs will be in a .CSV spreadsheet format.

For data generated by MEL, case narratives will be sent to the project manager via email and electronic data will be delivered through LIMS into the internal PTDB.

MEL contracted laboratory data will be submitted back to MEL as a fully paginated and bookmarked comprehensive .PDF file, with all contract-specified content, along with the EDD (.CSV). Smaller files may be sent through email, while larger files may be required to be submitted on compact disk. MEL will deliver case narratives in PDF format, and final EDDs with MEL-amended result and MEL-amended qualifier columns in an Excel spreadsheet format, to the project manager via email. Contract laboratories will be provided with the EDD template and EDD Help documents at the time of the request of services.

11.4 EIM/STORET data upload procedures

NA. Section 11.1 describes the database where data will be stored for this project.

11.5 Model information management

NA

12.0 Audits and Reports

12.1 Field, laboratory, and other audits

Analytical laboratories must participate in performance and system audits of their routine procedures.

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

12.2 Responsible personnel

Ecology's QA Officer or her/his designee will conduct the product testing process audit. 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 short report summarizing the data and findings will include, at a minimum:

- An overview of the study.
- Clear and concise goals and objectives of the study.
- General descriptions of products purchased.
- A summary of FTIR screening results.
- All the XRF raw data or a summary of the raw data will be attached or available on request in an excel format.
- A summary of laboratory results.
- Discussion of laboratory results and data quality.
- Conclusions.

12.4 Responsibility for reports

The project manager/principal investigator will have lead responsibility for the final report.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

The project manager, or assigned and qualified designee, will conduct a final review of product entry and screening data generated within a project.

All data entered into the PTDB will be reviewed by HQ staff at several stages during each study according to the *Product Testing Database SOP for Data Entry and Data Entry Quality Assurance* (SOP PTP002).

13.2 Laboratory data verification

Laboratory data verification is a review process to assess the quality and completeness of analytical data. A detailed examination of all lab data sets includes a review for errors, omissions, interpretations, calculations, qualifications, and compliance with all appropriate QC acceptance criteria and contract requirements. MEL's SOPs for data reduction, review, and reporting will meet the needs of the project. Contract lab Tier 4 level data packages will be assessed by MEL's QA Coordinator following MEL's SOPs and the EPA *National Functional Guidelines for Organic Data Review* (EPA, 2017).

Case narratives will be generated by lab staff and submitted, along with the lab data, to the project managers. The narrative will include a discussion describing if (1) MQOs are met, (2) proper analytical methods and protocols were followed, (3) calibrations and controls were within limits, and (4) data were consistent, correct, and complete, without errors or omissions (Sekerak, 2016a).

The project manager/principal investigator, with guidance of a QA representative as necessary, will be responsible for the final acceptance of the lab data. The contract lab case narratives and electronic data deliverable, along with MEL's written report, will be assessed for completeness and reasonableness. Based on these assessments, the data will be either accepted, accepted with qualifications, or rejected and re-analysis considered.

13.3 Validation requirements, if necessary

MEL's SOPs for data reduction, review, and reporting will meet the needs of the project. For contract lab data, conduct an EPA Stage 3 validation using the recommended verification and validation checks described in EPA Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (EPA, 2009), or equivalent. During Stage 3 validation, recalculations include:

- The initial calibration (ICAL).
- Continuing calibration(s) (CCAL).
- QC sample results (LCS/LCSD/OPR (Ongoing Precision and Recovery), MS/MSD, LD (Laboratory Duplicate), as appropriate).
- Field sample result for one sample and duplicate, if analyzed.

- For one of each
  - Method or analysis type/technology,
  - Matrix.

13.4 Model quality assessment

NA

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

The project manager will assess the quality of the data based on case narratives and data packages. Laboratory QC tests will be examined to determine if the lab(s) met MQOs for method blanks, LCSs, duplicates, matrix spike samples, and surrogates when applicable. Reporting limits will be examined to ensure that the contract-defined reporting limit was met (Sekerak, 2016a).

Further assessments of duplicate and spike performance will be used to evaluate any effects of sample matrix on the data quality.

Blank evaluation will aid in determining contamination, interferences, and precision for samples with low concentrations near analytical detection limits.

The project final report will discuss data quality and whether the project objectives were met. If limitations in the data are identified, they will be noted.

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 below the reporting limit (Sekerak, 2016a).

14.3 Data analysis and presentation methods

The final short report will include a summary of the results. Data and simple summary statistics will be presented in tables and graphs. Example summary statistics may include minimum, maximum, and frequencies of detection.

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

14.4 Sampling design evaluation

The number and type of collected samples will be sufficient to meet the objectives of this study.

14.5 Documentation of assessment

Documentation of assessment will occur in the final report.

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16.0 Appendix: Acronyms, Abbreviations, and Glossary

Acronyms and Abbreviations

BDE-209	Decabromodiphenyl Ether
BTBPE	1,2-Bis(2,4,6-tribromophenoxy)ethane
CAS	Chemical Abstracts Service
CCAL	Continuing Calibration
CHCC	Chemicals of High Concern to Children
CRM	Certified Reference Materials
CSPA	Children's Safe Products Act
e.g.	For example
DBDPE	1,2-Bis(2,3,4,5,6-pentabromophenyl)ethane
DQO	Data Quality Objective
EAP	Environmental Assessment Program
Ecology	Washington State Department of Ecology
EDD	Electronic Data Deliverable
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
EPEAT	Electronic Product Environmental Assessment Tool
FR	Flame Retardant Chemical
FTIR	Fourier Transform Infrared Spectrometry
GC/ECNI-MS	Gas Chromatography Electron Capture Negative Ionization Mass Spectrometry
GC-HRMS	Gas Chromatography High Resolution Mass Spectrometry
GC-MS	Gas Chromatography Mass Spectrometry
HBCD	Hexabromocyclododecane
HQ	Ecology Headquarters in Lacey
HWTR	Hazardous Waste and Toxics Reduction
ICAL	Initial Calibration
ID	Identification
LC-MSMS	Liquid Chromatography-Tandem Mass Spectrometry
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LD	Laboratory Duplicate
LIMS	Laboratory Information Management System
LLOQ	Lower Limit Of Quantitation
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
MRL	Method Reporting Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
N/A	Not Applicable
OPR	Ongoing Precision and Recovery
P2RA	Pollution Prevention and Regulatory Assistance
PBT	Persistent, bioaccumulative, and toxic substance

PTDB	Product Testing Database
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
PM	Project Manager
RCW	Revised Code of Washington
RDP	Resorcinol Bis(Diphenyl Phosphate)
RPD	Relative percent difference
RSD	Relative standard deviation
SCS	Statewide Coordination Section
SOP	Standard operating procedure
2,4,6-TBP	2,4,6-Tribromophenol
TBBPA	Tetrabromobisphenol A
TFF	Toxic-Free Future
TPP	Triphenyl Phosphate
TTBP-TAZ	Tris(2,4,6-tribromophenoxy)-1,3,5-triazine
UL	Underwriters Laboratories
WAC	Washington Administrative Code
WO	Work Order
XRF	X-ray Fluorescence

Units of Measurement

mg/kg	milligrams per kilogram (parts per million)

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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