



Quality Assurance Project Plan Assessment of Toxic Chemicals in Artificial Turf and Ground Cover Components

By

Lyndsey Smith and Amy Salamone

For the

Environmental Assessment Program

Washington State Department of Ecology

Olympia, Washington

April 2026, Publication 26-03-109

Publication Information

Each study conducted by the Washington State Department of 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 study's final report to the Internet.

This QAPP was approved to begin work in August 2025. It was finalized and approved for publication in April 2026.

The final QAPP is available on Ecology's website at <https://apps.ecology.wa.gov/publications/SummaryPages/2603109.html>.

Suggested Citation

Smith, L. and A. Salamone. 2026. Quality Assurance Project Plan: Assessment of Toxic Chemicals in Artificial Turf Components. Publication 26-03-109. Washington State Department of Ecology, Olympia. <https://apps.ecology.wa.gov/publications/SummaryPages/2603109.html>.

Data for this project are available in Ecology's [Consumer Products Database](#).¹ Search Study ID: Artificial Turf Components.

The Activity Tracker Code for this study is 25-011.

Federal Clean Water Act 1996 303(d) Listings Addressed in this Study. See Section 3.3.

COVER PHOTO: Close up of white and green artificial turf field during day. Photo by Fabricio Trujillo from pexels.com.

Any use of product or firm names in this publication is for descriptive purposes only and does not imply endorsement by the author or the Department of Ecology.

Contact Information

Publications Coordinator
Environmental Assessment Program
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
Phone: 564-669-3028

Washington State Department of Ecology – <https://ecology.wa.gov>

The Department of Ecology is committed to providing people with disabilities access to our information and services by meeting or exceeding the requirements of state and federal laws.

To request an ADA accommodation, email EAPpubs@ecy.wa.gov, call (564)-669-3028, or call Ecology through the Washington Telecommunication Relay for services, including text telephone (TTY) at 711 or through your preferred relay service provider. Visit <https://ecology.wa.gov/accessibility> for more accessibility information.

¹ <https://apps.ecology.wa.gov/ptdbreporting/>

Department of Ecology's Region Offices

Map of Counties Served



Southwest Region
360-407-6300

Northwest Region
206-594-0000

Central Region
509-575-2490

Eastern Region
509-329-3400

Region	Counties Served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	PO Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
Headquarters	Across Washington	PO Box 47600 Olympia, WA 98504	360-407-6000

Quality Assurance Project Plan

Assessment of Toxic Chemicals in Artificial Turf and Ground Cover Components

By Lyndsey Smith and Amy Salamone
April 2026

QAPP Approval Signatures

Signature: _____ Date: _____

Sean Smith, Product Replacement Program (PRP) Coordinator, HWTR

Signature: _____ Date: _____

Elaine Snouwaert, PRP Section Manager, Eastern Regional Office, HWTR

Signature: _____ Date: _____

Lyndsey Smith, Author, Project Manager, Product Studies Unit, EAP

Signature: _____ Date: _____

Amy Salamone, Co-author, Principal Investigator, Product Studies Unit, EAP

Signature: _____ Date: _____

Sara Sekerak, Author's Unit Supervisor, Product Studies Unit, EAP

Signature: _____ Date: _____

Jessica Archer, Author's Section Manager, Statewide Coordination Section, EAP

Signature: _____ Date: _____

Rob Waldrop, Director, Manchester Environmental Lab, EAP

Signature: _____ Date: _____

Christina Frans, Ecology Quality Assurance Officer

EAP: Environmental Assessment Program

HWTR: Hazardous Waste and Toxics Reduction

Signatures are not available on the Internet version.

1.0 Table of Contents

	Page
1.0 Table of Contents	2
List of Figures	5
List of Tables	5
2.0 Abstract	6
3.0 Background	7
3.1 Introduction and problem statement.....	7
3.2 Study area and surroundings	8
4.0 Project Description	15
4.1 Project goals.....	15
4.2 Project objectives.....	15
4.3 Information needed and sources.....	15
4.4 Tasks required	16
4.5 Systematic planning process.....	16
5.0 Organization and Schedule	17
5.1 Key individuals and their responsibilities	17
5.2 Special training and certifications.....	18
5.3 Organization chart	18
5.4 Proposed project schedule	18
5.5 Budget and funding.....	19
6.0 Quality Objectives	21
6.1 Data quality objectives.....	21
6.2 Measurement quality objectives	21
6.3 Acceptance criteria for quality of existing data	25
6.4 Model quality objectives.....	25
7.0 Study Design	26
7.1 Study boundaries	26
7.2 Field data collection	26
7.4 Assumptions underlying design	29

7.5	Possible challenges and contingencies	29
8.0	Field Procedures.....	31
8.1	Invasive species evaluation.....	31
8.2	Measurement and sampling procedures.....	31
8.3	Containers, preservation methods, holding times	33
8.4	Equipment decontamination	36
8.5	Sample ID	36
8.6	Chain of custody	36
8.7	Field log requirements	36
8.8	Other activities.....	36
9.0	Laboratory Procedures	37
9.1	Lab procedures table	37
9.2	Sample preparation method(s).....	37
9.3	Special method requirements	38
9.4	Laboratories accredited for methods	38
10.0	Quality Control Procedures.....	39
10.1	Table of field and laboratory quality control	39
10.2	Corrective action processes	39
11.0	Data Management Procedures	40
11.1	Data recording and reporting requirements	40
11.2	Laboratory data package requirements	40
11.3	Electronic transfer requirements.....	40
11.4	Consumer Product Database data upload procedures	40
11.5	Model information management	40
12.0	Audits and Reports.....	41
12.1	Field, laboratory, and other audits	41
12.2	Responsible personnel.....	41
12.3	Frequency and distribution of reports.....	41
12.4	Responsibility for reports.....	41
13.0	Data Verification	42

13.1	Field data verification, requirements, and responsibilities	42
13.2	Laboratory data verification	42
13.3	Validation requirements, if necessary	42
13.4	Model quality assessment	42
14.0	Data Quality (Usability) Assessment	43
14.1	Process for determining project objectives were met	43
14.2	Treatment of non-detects.....	43
14.3	Data analysis and presentation methods	43
14.4	Sampling design evaluation	43
14.5	Documentation of assessment	43
15.0	References	44
16.0	Appendices	52
	Appendix A. Glossaries, Acronyms, and Abbreviations	52

List of Figures

Figure 1. Map of four regional study areas in Washington.	8
Figure 2. Example sample collection locations for rectangular-shaped installations (EPA ORD 2018).	27
Figure 3. Example sample locations for diamond-shaped installations with and without artificial turf infields (EPA ORD 2018).	28

List of Tables

Table 1. Metals of interest in this study.	10
Table 2. Organic compound chemicals of interest in this study.	11
Table 3. Organization of project staff and responsibilities.	17
Table 4. Schedule for completing field and laboratory work.	18
Table 5. Schedule for final report.	19
Table 6. Project budget and funding.	19
Table 7. Laboratory budget details.	20
Table 8. Measurement quality objectives for field and laboratory organic analyses of artificial turf component samples.	21
Table 9. Measurement quality objectives for field and laboratory inorganic analyses of artificial turf component samples.	23
Table 10. Sample containers, preservation, and holding times.	35
Table 11. Measurement methods (laboratory).	37
Table 12. Quality control samples, types and frequency.	39

2.0 Abstract

Artificial turf and artificial ground cover products have been installed in many communities for use as athletic playfields, playgrounds, park ground cover, and for landscape mulching. Artificial ground covers can include rubber surfacing used as playground flooring and running tracks, as well as rubber mulches used in a variety of applications. The materials used in artificial turf and ground cover installations have changed over time, and vary across installations, complicating the task of assessing potential environmental impact. This study will measure specific toxic chemicals in artificial components from ground cover installations across Washington State. Samples will consist of artificial turf and ground cover components made of different materials, including turf blades, rubber mats, mulches, crumb rubber, and alternative infill types, running tracks, and playground flooring. Findings from this study and a companion stormwater runoff study (Salamone 2025) will inform the Product Replacement Program in the development of an artificial turf replacement program.

3.0 Background

3.1 Introduction and problem statement

Removing toxic chemicals from consumer products before they cause personal or environmental harm is one of the most effective ways to protect Washington's public health, environment, and economy. In collaboration with local governments, Washington State Department of Ecology's (Ecology) Hazardous Waste and Toxic Reduction (HWTR) Program provides financial incentives to Washington businesses and organizations through the Product Replacement Program (PRP) to remove or replace toxic chemicals through product upgrades, 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 monitors the release and persistence of toxic chemicals in the environment. HWTR Program will use findings from this study and the artificial turf stormwater runoff study (Salamone 2025) to potentially develop an artificial turf replacement program.

Artificial turf is synthetic grass installed to mimic the appearance of natural grass. Artificial turf has become increasingly popular, with overall sales in North America increasing by 15% since 2017 (STC 2020). In North America, there are an estimated 16,000 artificial turf fields and 65 million square feet of installed artificial turf (Penta Group 2022; DTSC 2024). Artificial turf fields have estimated lifespans ranging between 5 and 15 years (STC 2020). Since natural turf requires periods of inactivity to recover and remain healthy, artificial turf fields can provide more playing time and be used for more events on the same surface than natural turf (Cheng et al. 2014).

Artificial ground covers also include rubber surfacing used as playground flooring and running tracks, as well as rubber mulches used in a variety of applications.

Artificial turf is generally installed with several components, and may include a base layer of gravel and sand, a layer of turf backing material, turf blades, and one or more infill types. Sports fields may also have an optional shock-absorbing pad. Turf blades are commonly made of extruded polyethylene, nylon, or polypropylene that is cut into strips, twisted together, and stitched or tufted into the backing material (Jastifer et al. 2019). The most common type of turf infill used on sports fields is crumb rubber, which is mostly made of shredded end-of-life tires (STC 2020). Other types of rubber, such as ethylene propylene diene terpolymer (EPDM), thermoplastic elastomer (TPE), and waste athletic shoe materials, may be used (Bauer et al. 2017; Jastifer et al. 2019; Massey et al. 2020). Alternative turf infill materials available include cork, sand, coconut fiber, olive pits, and engineered wood particles. An average artificial turf sports field contains about 40,000 pounds of infill and 40,000 pounds of turf blades and backing (STC 2020).

Extensive literature has been generated on chemicals present in, and released from, artificial turf blades, turf backing materials, and crumb rubber infill (see Section 3.2.2). Plastics and rubbers used in artificial turf and ground cover components are often manufactured with stabilizing additives. These additives are designed to withstand environmental and human

influences such as sunlight, temperature changes, rainfall, playing, maintenance, and cleaning (Bertling et al. 2021).

This study is designed to investigate artificial turf and ground cover components as sources of toxic chemicals at locations assessed in the companion stormwater runoff study (Salamone 2025). Chemical analysis will include testing for arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), nickel (Ni), and zinc (Zn), and toxic chemicals N-(1,3- Dimethylbutyl)-N'-phenyl-p-phenylenediamine-quinone (6PPDQ) and 40 per- and polyfluoroalkyl substances (PFAS).

3.2 Study area and surroundings

This study will use four regional areas of Washington to group and code field site locations (Figure 1). Artificial turf and ground cover materials are used across Washington State to promote outdoor activity and support youth athletics and community events. There are likely over 500 artificial turf fields, running tracks, and playgrounds installed for use at county or city parks, regional event centers, Tribal parks, universities, and public and private schools in Washington. Artificial turf and ground cover installations are located primarily near more heavily populated areas of the northwest and southwest regions of Washington. As of 2020, the population residing in the northwest region is 3,834,276, the southwest region is 2,202,261, the central region is 796,110, and the eastern region is 873,681 (OFM 2024).



Figure 1. Map of four regional study areas in Washington.

3.2.1 History of study area

This study is designed to sample from installations of variable ages and use-types. Most artificial turf and ground cover installations are used for playing sports, like football, baseball, track and soccer, while others may serve as school or community playgrounds.

3.2.2 Summary of previous studies and existing data

This quality assurance project plan (QAPP) summarizes previous studies of artificial turf materials for 6PPD-quinone, PFAS, and metals that will be measured in this study. This section is not meant to serve as a comprehensive resource for all toxic chemicals that have been

detected in artificial turf component materials. Studies have been published on many other chemicals present in, and released from, artificial turf blades, turf backing materials, and crumb rubber infill (Bocca et al. 2008; Menichini et al. 2011; Kruger et al. 2012; Cheng et al. 2014; Massey et al. 2020; Gomes et al. 2021; Zhang et al. 2021; Murphy and Warner 2022; Ferreira et al. 2024; McMinn et al. 2024)

6PPD (N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine) is a rubber protectant added to most vehicle tires at 1 to 2% (10,000 to 20,000 µg/g) (DTSC 2022). Crumb rubber infill is made almost exclusively of recycled vehicle tires. When 6PPD reacts with oxygen, it forms 6PPD-quinone (6PPDQ), a chemical that was recently discovered to be highly toxic to coho salmon, which is very concerning to Washington (Tian et al. 2021; Ecology 2022a). A study of crumb rubber samples from artificial turf infills across the U.S. tentatively identified 6PPD but did not quantify it (EPA and CDC 2019). A recent study collected and analyzed crumb rubber infill from 9 artificial turf locations in Washington and found that all crumb rubber samples contained measurable 6PPD and 6PPDQ (Zhao et al. 2023). Results of a laboratory study indicate that warm weather may cause faster formation and release of 6PPDQ from crumb rubber infill than in cold weather (Zhao et al. 2024).

Per- and polyfluoroalkyl substances (PFAS) are a group of synthetic fluorinated compounds with a wide variety of physical and chemical properties. Manufacturers use fluoropolymers, a subset of PFAS, in production processes. Fluoropolymers lower surface energy to reduce processing issues, improve extrusion of products, and increase the efficiency and quality of manufacturing (Buck et al. 2011; Glüge et al. 2020; Lohmann et al. 2020; 3M n.d.; Goodrow 2023). Studies have documented that fluoropolymer production and breakdown byproducts can result in additional PFAS compounds, which may remain on the product itself as processing residuals (Lohmann et al. 2020; TURI 2020; Goodrow 2023).

Fluoropolymers such as polytetrafluoroethylene (PTFE) and polyvinylidene fluoride (PVDF) are intentionally used during the manufacturing process of artificial turf blades and infill materials (Lambert 2008; Reddick 2012; Wu 2020). Other PFAS compounds have been detected when different components of the artificial turf are tested (Lauria et al., 2022; Zuccaro et al., 2023). The use of recycled materials in manufacturing may also incorporate additional PFAS into artificial turf components (Goodrow 2023). Studies have detected PFAS in artificial turf materials by assessing specific PFAS compounds, total fluorine, extractable organic fluorine, fluoride analysis, and/or total oxidizable precursor assay (Lauria et al. 2022; Zuccaro et al. 2023). An assessment of a small class of PFAS (fluorotelomer alcohols) indicates that samples of turf backing, plastic grass blades, and crumb rubber infill contained 8:2 fluorotelomer alcohol (Zuccaro et al. 2023). In general, PFAS analysis is challenging since PFAS in artificial turf materials are difficult to extract (Lauria et al. 2022). Peer-reviewed studies are discussed below.

Zuccaro et al. analyzed a single new artificial turf fiber and crumb rubber sample obtained from the manufacturer. Fluorotelomer alcohol (8:2 FTOH) was detected at 300 parts per billion (ppb) in artificial turf fiber and 110 ppb in crumb rubber (Zuccaro et al., 2023). Fluorotelomer alcohols have the potential to biodegrade or environmentally degrade into perfluorocarboxylic acids (PFCAs), such as perfluorooctanoic acid (PFOA) and perfluorononanoic acid (PFNA) (Dinglasan

et al., 2004; Wallington et al., 2006). While the Zuccaro et al. study was limited to one newly manufactured turf sample, it provides evidence for PFAS within artificial turf.

A 2020 study tested components from 17 athletic turf fields in Stockholm, Sweden (Lauria et al. 2022). Turf blades, infill, and backing were analyzed for total fluorine (TF), extractable organic fluorine (EOF), target PFAS, and total oxidizable precursor assay (TOPA). Total fluorine analysis detected the presence of fluorine in all samples. Analysis using EOF and targeted PFAS found detectable levels of organic fluorine at a lower magnitude in less than 42% of the samples.

Early and current research has focused on assessing metals present in or leaching from artificial turf materials. Several studies have detected the metals cadmium, copper, lead, nickel, and zinc associated with artificial turf materials, mainly from crumb rubber infill (CPSC 2008; Li et al. 2010; Menichini et al. 2011; Pavilonis et al. 2014; Cheng et al. 2014; Marsili et al. 2014; Vineyard et al. 2018; Massey et al. 2020; Zhang et al. 2021; Grynkiewicz-Bylina et al. 2022). Heavy metals have been identified in turf blades, and studies indicate that the amount and types of metals present may vary depending on turf blade color (DTSC 2024; Vineyard et al. 2018; Van Ulirsch 2010).

3.2.3 Parameters of interest and potential sources

Tables 1 and 2 present the chemicals of interest for this study.

Table 1. Metals of interest in this study.

Abbreviation	Chemical Name	CAS RN
As	Arsenic	7440-38-2
Cd	Cadmium	7440-43-9
Cu	Copper	7440-50-8
Pb	Lead	7439-92-7
Ni	Nickel	7440-02-0
Zn	Zinc	7440-66-6

Table 2. Organic compound chemicals of interest in this study.

Abbreviation	Chemical Name	CAS RN
6PPDQ	N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine-quinone	2754428-18-5
PFBA	Perfluorobutanoate	45048-62-2
PFPeA	Perfluoropentanoate	45167-47-3
PFHxA	Perfluorohexanoate	92612-52-7
PFHpA	Perfluoroheptanoate	120885-29-2
PFOA	Perfluorooctanoate	45285-51-6
PFNA	Perfluorononanoate	72007-68-2
PFDA	Perfluorodecanoate	73829-36-4
PFUnA	Perfluoroundecanoate	196859-54-8
PFDoA	Perfluorododecanoate	171978-95-3
PFTTrDA	Perfluorotridecanoate	862374-87-6
PFTeDA	Perfluorotetradecanoate	365971-87-5
PFBS	Perfluorobutane sulfonate	45187-15-3
PFPeS	Perfluoropentane sulfonate	175905-36-9
PFHxS	Perfluorohexane sulfonate	108427-53-8
PFHpS	Perfluoroheptane sulfonate	146689-46-5
PFOS	Perfluorooctane sulfonate	45298-90-6
PFNS	Perfluorononane sulfonate	474511-07-4
PFDS	Perfluorodecane sulfonate	126105-34-8
PFDoS	Perfluorododecane sulfonate	343629-43- 6
4:2 FTS	1H,1H,2H,2H-Perfluorohexane sulfonate	414911-30-1
6:2 FTS	1H,1H,2H,2H-Perfluorooctane sulfonate	425670-75-3
8:2 FTS	1H,1H,2H,2H-Perfluorodecane sulfonate	481071-78-7
PFOSA	Perfluorooctanesulfonamide	754-91-6
NMeFOSA	N-methyl perfluorooctanesulfonamide	31506-32-8
NEtFOSA	N-ethyl perfluorooctanesulfonamide	4151-50-2
NMeFOSAA	N-methyl perfluorooctanesulfonamidoacetate	none
NEtFOSAA	N-ethyl perfluorooctanesulfonamidoacetate	none
NMeFOSE	N-methyl perfluorooctanesulfonamidoethanol	24448-09-7

Abbreviation	Chemical Name	CAS RN
NEtFOSE	N-ethyl perfluorooctanesulfonamidoethanol	1691-99-2
HFPO-DA/GenX	2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)propanoate	122499-17-6
ADONA	4,8-Dioxa-3H-perfluorononanoate	2127366-90-7
PFMPA	Perfluoro-3-methoxypropanoate	none
PFMBA	Perfluoro-4-methoxybutanoate	1432017-36-1
NFDHA	Nonafluoro-3,6-dioxaheptanoate	39187-41-2
9Cl-PF3ONS	9-chlorohexadecafluoro-3-oxanonane-1-sulfonate	1621485-21-9
11Cl-PF3OUdS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonate	2196242-82-5
PFEESA	Perfluoro(2-ethoxyethane)sulfonate	220689-13-4
3:3 FTCA	3-Perfluoropropyl propanoate	1169706-83-5
5:3 FTCA	2H,2H,3H,3H-Perfluorooctanoate	1799325-94-2
7:3 FTCA	3-Perfluoroheptyl propanoate	1799325-95-3

Artificial turf layers can be comprised of a variety of materials, including nylon, polyethylene, polypropylene, polyurethane, and synthetic rubber. The synthetic rubber is often sourced from crumb rubber from discarded tires or tire materials (Murphy and Warner 2022).

Tire wear particles are known to contain contaminants such as 6PPDQ (Smith 2023), and several studies have identified the presence of 6PPDQ in outdoor dust (Huang et al. 2021; Cao et al. 2022; Deng et al. 2022; Ihenetu 2025). While much ongoing research focuses on tires as a source of 6PPDQ, other consumer products made with rubber may also be a source of 6PPDQ (Sherman et al. 2025; Zhao et al. 2024).

PFAS chemicals have been found in densely populated and remote, unpopulated areas worldwide (Pfortenhauer et al. 2022). There are no known PFAS manufacturers in Washington State. Atmospheric deposition of PFAS may be a potential non-point source of PFAS contamination (Pfortenhauer et al. 2022; Ecology 2024).

Environmental deposition of heavy metals is a widely researched topic. Metals pollution can occur from a wide range of sources, including industrial processes, agriculture, and other human activities (Tchounwou et al. 2012). Particles from tire wear, brake pads, and roofing have been identified as a source of heavy metal pollution in Washington State (Ecology 2011). Industrial and agricultural processes are likely an additional contributor to metals pollution.

This study is designed to assess selected existing installations of artificial turf and ground cover components for 6PPDQ, PFAS, and metals. Installations included in this study were also participants in the companion stormwater runoff study. Several factors can influence the concentrations of chemicals detected in installed artificial turf and ground cover components. Upon collection, components may contain chemicals from the manufacturing process,

installation process, contamination during use, and environmental contamination like air and rain deposition. Other environmental or contamination sources of 6PPDQ, PFAS, or metals cannot be determined in this study, and results are not intended to predict conditions at artificial installations not included in this study.

6PPDQ

While automobile tires are currently understood to be a major source of 6PPD and 6PPDQ, more research is needed to evaluate additional consumer product sources of 6PPD (Ecology 2022a; DTSC 2022; Zhao et al. 2023). Since many athletic artificial turf fields use recycled tire crumb rubber as infill, they may be a source for 6PPDQ in the environment (Smith 2023).

PFAS

Artificial grass blades, infill, and backing may contain PFAS. Polymeric PFAS used in the manufacturing process can remain in the product indefinitely. PFAS are used in plastic artificial grass blades as an extrusion aid to keep the plastic from sticking to the extruder as it is melted and shaped (Glüge et al. 2020). The production uses of PFAS may indicate why PFAS have been found in artificial turf (Lauria et al. 2022; Zuccaro et al. 2023). Over time, artificial turf components degrade, releasing PFAS and PFAS-containing microplastics into the environment (Lauria et al. 2022; Kole et al. 2023; Zuccaro et al. 2023). PFAS are persistent in the environment and can bioaccumulate in wildlife or travel in our waterways.

Metals

Metals are known to be present in recycled tire crumb rubber infill. Certain metals may also be used as colorants or stabilizers in artificial grass blades, like green copper metallic complexes or mixed metal-oxide pigments (Vineyard et al. 2018; DTSC 2024). Heavy metals such as arsenic, cadmium, copper, lead, nickel, and zinc have been identified as chemicals of concern (Ecology and King County 2011). Some heavy metals are known to cause health effects such as cancers, internal organ damage, cardiovascular disease, and developmental delays in children. Many heavy metals are toxic to aquatic organisms and can bioaccumulate in the environment and in wildlife (Emon et al. 2023).

3.2.4 Regulatory criteria or standards

This study does not collect data to determine compliance with any regulatory standards. In November 2024, artificial turf was identified in the Priority Product Report to the Legislature in support of Safer Products for Washington (70A.350 RCW).

The Persistent Bioaccumulative Toxins Rule (Chapter 173-333 WAC), which was passed in 2003, establishes a process for Ecology to address persistent bioaccumulative toxins (PBTs). PBTs are chemicals that stay in the environment for a long time, accumulate in plants, animals, and people, and cause immediate or long-term toxic effects. Under Washington's PBT Rule, Ecology can identify individual chemicals or groups of chemicals as bioaccumulative toxins and develop Chemical Action Plans (CAP). CAPs recommend actions to protect human health and the environment. While they do not ban or regulate chemicals, recommendations in these plans can lead to legislative or regulatory action.

In 2022, House Bill 1694 gave Ecology authority to address PFAS in products named in the PFAS Chemical Action Plan as a priority product under the Safer Products for Washington program (70A.350 RCW). The first set of regulations will restrict PFAS in carpet, textile, and leather furnishings, as well as in aftermarket stain and water resistance treatments.

In March 2024, the Washington State Legislature added 6PPD as a priority chemical and tires as a priority product to the current cycle of the Safer Products for Washington program (70A.350 RCW). If a safer, feasible, and available alternative is identified, rulemaking can restrict the use of 6PPD in tires. An action plan detailing current knowledge and data gaps was finalized and submitted to the legislature in November 2024, providing a progress report on actions identified to find solutions to 6PPD and 6PPDQ.

4.0 Project Description

This study is designed to assess whether components in artificial turf and ground cover installations in Washington contain PFAS, 6PPDQ, and metals. Community members and field owners are concerned about the potential toxic chemical exposure of those who use the installations, as well as the potential for chemical leaching from these installations into the environment. Study data will inform the Product Replacement Program regarding potential development of an artificial turf replacement program, potentially offering financial support for new installations with less-toxic options.

4.1 Project goals

The primary goal of this study is to identify the presence and concentrations of PFAS, 6PPDQ, and metals in the components of artificial turf and ground covers currently installed in Washington.

4.2 Project objectives

Project objectives to meet the goal of this study:

- Collect at least 60 samples of components from up to 30 artificial turf and ground covers currently installed in Washington State. Components may include plastic turf blades, turf backing, shock pad, infill, and rubber mulch.
- Analyze PFAS, 6PPDQ, and metals in at least 60 samples of artificial turf and ground cover components with up to 30 quality control samples.

4.3 Information needed and sources

Priority will be given to currently installed fields and ground covers that were assessed in the companion stormwater runoff study, and those for which product installation information is available. To gather product information, the principal investigator will ask field owners or designated representatives the following list of questions:

- When was your artificial turf installed?
- What type of infill is used at your installation?
- Has the infill been replaced or changed at the installation? When?
- Does your installation include the optional shock pad below the turf?
- What are the brands of artificial turf products at the installation? (Artificial Turf, Turf Infill, Shock Pad).

4.4 Tasks required

The following tasks will be performed for this study:

- Obtain permission from and coordinate with participating fields from the related artificial turf runoff study (Salamone 2025).
- Coordinate with Manchester Environmental Laboratory (MEL) during project planning and sample submission.
- Request EPA approval for consumer product testing at MEL.
- Request accreditation waiver for 6PPDQ by Standard Operating Procedure (SOP) MEL730136.
- Collect at least 60 product component samples and submit them to MEL for 6PPDQ, and metals analysis following the schedule in section 8.3.
- Collect at least 60 product component samples and submit them to a contract laboratory for PFAS analysis following the schedule in section 8.3.
- Review laboratory data and data validation report.
- Document and publish results into Ecology's Consumer Products Database (CPD).
- Write and publish study results in a report.

4.5 Systematic planning process

This QAPP represents systematic planning for this study.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 3. shows the responsibilities of those who will be involved in this project.

Table 3. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Sean Smith Product Replacement Program, HWTR Eastern Regional Office Phone: 425-324-0328	PRP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP. Approves final report.
Elaine Snouwaert Product Replacement Program HWTR Eastern Regional Office Phone: 509-385-5169	PRP Section Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Lyndsey Smith Product Studies Unit Statewide Coordination Section, EAP Phone: 564-669-4335	Project Manager	Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of lab data, analyzes and interprets data. Writes the draft report and final report.
Amy Salamone Product Studies Unit Statewide Coordination Section, EAP Phone: 564-669-1760	Principal Investigator	Co-authors the QAPP. Assists with field sampling. Coordinates with field owners. Assists with draft report.
Jenna Rushing Product Studies Unit Statewide Coordination Section, EAP Phone: 360-819-3670	Field Assistant	Helps collect samples and records field information. Conducts QA review of sample data.
Sara Sekerak Product Studies Unit Statewide Coordination Section, EAP Phone: 360-480-9501	Unit Supervisor for Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP. Approves final report.
Jessica Archer Statewide Coordination Section, EAP Phone: 360-890-2721	Section Manager for Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.

Staff	Title	Responsibilities
Rob Waldrop Manchester Environmental Laboratory Phone: 564-669-4869	Lab Director	Reviews and approves the final QAPP, ensures timely and accurate completion of analysis and data deliverables.
Contract Laboratory	Project Manager	Reviews draft QAPP, coordinates with MEL, ensures timely and accurate completion of analysis and data deliverables.
Christina Frans 360-995-2473	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP. Signs the Approval to Begin Work form.

EAP: Environmental Assessment Program; PRP: Product Replacement Program; QAPP: Quality Assurance Project Plan; HWTR: Hazardous Waste and Toxics Reduction.

5.2 Special training and certifications

All field staff will be trained to conduct component sampling following safety and quality assurance guidelines outlined in section 8. Training includes special procedures for avoiding cross-contamination, equipment decontamination procedures, and proper storage and transport of field samples to the designated laboratories.

5.3 Organization chart

Not Applicable – See Table 3

5.4 Proposed project schedule

Tables 4 and 5 list key activities, due dates, and lead staff for this project.

Table 4. Schedule for completing field and laboratory work.

Task	Due Date	Lead Staff
Field work	December 31, 2025	Lyndsey Smith/Amy Salamone
Sample submission to MEL	December 31, 2025	Jenna Rushing
Sample submission to contract lab	December 31, 2025	Jenna Rushing
Cryomilling	March 31, 2026	Contract Lab
Laboratory analyses	June 20, 2026	Contract Lab/MEL
Lab data validation	December 7, 2026	MEL

Table 5. Schedule for final report.

Task	Due Date	Lead Staff
Draft to supervisor	January 30, 2026	Lyndsey Smith/Amy Salamone
Draft to client/ peer reviewer	February 30, 2026	Lyndsey Smith/Amy Salamone
Draft to external reviewers	February 30, 2026	Lyndsey Smith/Amy Salamone
Final draft to publications team	March 30, 2027	Lyndsey Smith/Amy Salamone
Final report due on web	May 30, 2027	EAP Pubs

5.5 Budget and funding

Tables 6 and 7 show budget details for this study.

Table 6. Project budget and funding.

Item	Cost (\$)
Equipment	\$2000
Shipping	\$2000
Travel and other	\$6000
Laboratory (See Table 6 for details)	\$110,320
Project Total	\$121,700

Table 7. Laboratory budget details.

Parameter	Number of Samples	Number of QC Samples*	Total Number of Samples	Cost Per Sample (\$)	Lab Subtotal (\$)
Cryomilling	≥ 66	14	80	\$80	\$6400
6PPDQ	≥ 66	12 [±]	78	\$345	\$26910
Metals (6 elements)	≥ 66	16	82	\$209	\$17138
PFAS (40 compounds)	≥ 66	12 [±]	78	\$405	\$31590
Cryomill Blanks (6PPDQ)	≥16**	—	16	\$345	\$5520
Cryomill Blanks (PFAS)	≥16**	—	16	\$405	\$6480
Equipment ^π Blanks (6PPDQ)	≥ 6	—	6	\$345	\$2070
Equipment Blanks (Metals)	≥ 6	—	6	\$209	\$1254
Equipment Blanks (PFAS)	≥ 6	—	6	\$405	\$2430
MEL Contract Lab Fee	—	—	230	15% of PFAS and cryomill total	\$7448
Contract Lab Data Deliverable Fee	—	—	88	\$35	\$3080
Laboratory Total					\$110,320

* The number of QC samples will depend on the number of batches. Per batch QC samples for metals to include 1 lab duplicate, 1 lab control sample (LCS), 1 lab method blank, and 1 lab matrix spike/matrix spike duplicate (MS/MSD).

[±] EPA Method 1633 and MEL SOP 730140 utilize extracted internal standards for each sample. PFAS and 6PPDQ QC samples will exclude MS/MSD.

** QC samples for cryomilling consist of rinsate blank checks collected at the beginning and end of each processing day. This number is estimated.

^π Equipment blanks will be for hand tools used to collect samples in the field.

6.0 Quality Objectives

6.1 Data quality objectives

The main data quality objective (DQO) for this project is to collect representative artificial turf and ground cover component samples and to have them analyzed. The analysis will use standard methods to obtain 6PPDQ, total PFAS, and metals concentration data that meet measurement quality objectives (MQOs) that are described below.

6.2 Measurement quality objectives

Measurement quality objectives are detailed in Tables 8 and 9.

6.2.1 Targets for precision, bias, and sensitivity

Table 8. Measurement quality objectives for field and laboratory organic analyses of artificial turf component samples.

Parameter	Lab, Field, Matrix Spike Duplicates (RPD)	Lab, Field Blanks	OPR/LLOPR (% Recovery)	Extracted Internal Standard (% Recovery)	MDL (ng/g)*
6PPDQ	≤40%	≤½ LLOQ	50–150	25–275	0.595 µg/kg
PFBA	±40%	<1/2 LLOQ	70–140	70–140	2.01
PFPeA	±40%	<1/2 LLOQ	60–150	70–140	0.10
PFHxA	±40%	<1/2 LLOQ	65–140	70–135	0.28
PFHpA	±40%	<1/2 LLOQ	65–145	70–140	0.14
PFOA	±40%	<1/2 LLOQ	70–150	70–140	0.18
PFNA	±40%	<1/2 LLOQ	70–155	65–145	0.43
PFDA	±40%	<1/2 LLOQ	70–155	70–145	0.40
PFUnA	±40%	<1/2 LLOQ	70–155	70–145	0.17
PFDoA	±40%	<1/2 LLOQ	70–150	70–145	0.30
PFTTrDA	±40%	<1/2 LLOQ	65–150	55–160	0.19
PFTeDA	±40%	<1/2 LLOQ	65–150	70–145	0.16
PFBS	±40%	<1/2 LLOQ	65–145	60–145	0.22
PFPeS	±40%	<1/2 LLOQ	55–160	65–140	0.08
PFHxS	±40%	<1/2 LLOQ	60–150	65–145	0.09

Parameter	Lab, Field, Matrix Spike Duplicates (RPD)	Lab, Field Blanks	OPR/LLOPR (% Recovery)	Extracted Internal Standard (% Recovery)	MDL (ng/g)*
PFHpS	±40%	<1/2 LLOQ	65–155	70–140	0.29
PFOS	±40%	<1/2 LLOQ	65–160	70–135	0.34
PFNS	±40%	<1/2 LLOQ	55–140	70–140	0.23
PFDS	±40%	<1/2 LLOQ	40–155	50–150	0.20
PFDoS	±40%	<1/2 LLOQ	25–160	40–140	0.19
4:2FTS	±40%	<1/2 LLOQ	60–150	70–135	1.41
6:2FTS	±40%	<1/2 LLOQ	55–200	60–160	10.04
8:2FTS	±40%	<1/2 LLOQ	70–150	70–140	1.12
PFOSA	±40%	<1/2 LLOQ	70–140	70–140	0.34
NMeFOSA	±40%	<1/2 LLOQ	70–155	65–145	0.24
NEtFOSA	±40%	<1/2 LLOQ	70–140	70–135	0.19
NMeFOSAA	±40%	<1/2 LLOQ	65–155	65–145	0.15
NEtFOSAA	±40%	<1/2 LLOQ	65–165	60–150	0.80
NMeFOSE	±40%	<1/2 LLOQ	70–140	70–140	1.01
NEtFOSE	±40%	<1/2 LLOQ	70–135	70–135	1.23
HFPO-DA/GenX	±40%	<1/2 LLOQ	70–145	70–140	0.68
ADONA	±40%	<1/2 LLOQ	70–160	70–155	0.29
PFMPA	±40%	<1/2 LLOQ	30–140	70–140	0.16
PFMBA	±40%	<1/2 LLOQ	70–130	55–145	0.15
NFDHA	±40%	<1/2 LLOQ	60–155	45–145	0.42
9Cl-PF3ONS	±40%	<1/2 LLOQ	70–150	65–135	0.45
11Cl-PF3OUdS	±40%	<1/2 LLOQ	45–160	50–135	0.35
PFEESA	±40%	<1/2 LLOQ	70–140	70–140	0.09
3:3FTCA	±40%	<1/2 LLOQ	45–130	45–155	0.30
5:3FTCA	±40%	<1/2 LLOQ	60–130	70–135	1.82
7:3FTCA	±40%	<1/2 LLOQ	60–150	70–145	1.54

RPD: relative percent difference

OPR/LLOPR: ongoing precision and recovery/low-level ongoing precision and recovery

MDL: method detection limit

LLOQ: lower limit of quantitation

*MDLs from the SGS Method for EPA 1633, adjusted for the reduction in sample size from 5 grams to 1 gram (MDLs multiplied by 5).

Table 9. Measurement quality objectives for field and laboratory inorganic analyses of artificial turf component samples.

Parameter	Lab, Field, Matrix Spike Duplicate (RPD)	Lab, Field Blanks	LCS/LCSD (% Recovery)	Matrix Spike (% Recovery)	Internal Standard Recovery (%Recovery)	MRL
As	±20%	< ½ MRL	85–115	75–125	60–125	10 mg/kg
Cd	±20%	< ½ MRL	85–115	75–125	60–125	10 mg/kg
Cu	±20%	< ½ MRL	85–115	75–125	60–125	10 mg/kg
Ni	±20%	< ½ MRL	85–115	75–125	60–125	10 mg/kg
Pb	±20%	< ½ MRL	85–115	75–125	60–125	10 mg/kg
Zn	±20%	< ½ MRL	85–115	75–125	60–125	50 mg/kg

LCS: laboratory control sample

LCSD: laboratory control sample duplicate

MRL: method reporting limit

RPD: relative percent difference

6.2.1.1 Precision

Precision is a measure of variability among replicate measurements due to random error. Field duplicate samples will be collected for every 10% of samples and analyzed alongside the field samples. Results from this study will be assessed for precision using duplicate field sample measurements, laboratory analysis of duplicate samples, and matrix spike duplicates. Precision for two duplicate samples will be measured as the relative percent difference between the two results. MQOs for precision are presented in Tables 7 and 8.

Precision for field scales used to measure sample weights is set at +/- 1.0 gram.

6.2.1.2 Bias

Bias is the difference between the sample mean and the true value. Bias will be evaluated and compared to method-specific limits by analyzing laboratory control samples and matrix spikes. Laboratory control samples contain known amounts of analyte and indicate bias due to sample preparation and/or calibration. Matrix spikes indicate bias due to matrix effects, and matrix spike duplicates provide an estimate of the precision of this bias. Tables 7 and 8 outline the MQOs for recoveries of laboratory control samples and matrix spikes.

6.2.1.3 Sensitivity

Sensitivity is a measure of a field sampling or laboratory method's ability to detect a substance.

Sensitivity for laboratory analyses is defined as the lower limit of quantification (LLOQ), minimum level of quantitation (ML), or the method reporting limit (MRL). See Tables 7 and 8 for specified laboratory method quantitation limits.

Field duplicates will be collected for 10% of samples to assess precision during the collection process and laboratory analysis.

Equipment blanks will be collected to assess contamination from collection equipment, including spoons and scissors. Equipment blanks will be collected in the field by swishing sample equipment in PFAS-free laboratory-grade water into a clean, PFAS-free sample container.

Preparation blanks will be collected to assess contamination from the cryomilling preparation step. Preparation blanks will be collected at the beginning and end of each processing day.

All samples will be evaluated against the associated method, equipment, and cryomill preparation blanks for each analytical or cryomill preparation batch. Sample results less than or equal to 5x the method, equipment, and cryomill preparation blank concentration will be qualified as non-detect due to lab background or contamination. Total PFAS calculations will only include detected results.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

As possible, this study will ensure comparability with other studies by using SOPs (see Section 8 for a list of SOPs) and standard laboratory methods.

6.2.2.2 Representativeness

Representativeness is a measure of whether the sample media reflects reality. As possible, we will ensure proper representation by adhering to the approved SOPs and sampling protocols in section 8. Samples collected for this study are only representative of the turf field components at the point in time at which they were collected, and do not represent the highest or lowest concentrations of 6PPDQ, PFAS, or metals that may be present in artificial turf and ground surface components (see section 7.4). Samples of the same weight will be collected at multiple locations and composited to ensure samples are representative of the whole field and do not over- or underrepresent any area of the field.

6.2.2.3 Completeness

Completeness is a measure of the amount of valid data necessary to meet project objectives. Issues such as site access, time constraints, and equipment malfunctions may affect the completeness of the data set. Since this is an investigative study that will not generate data used for modeling or compliance, there are no completeness criteria.

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

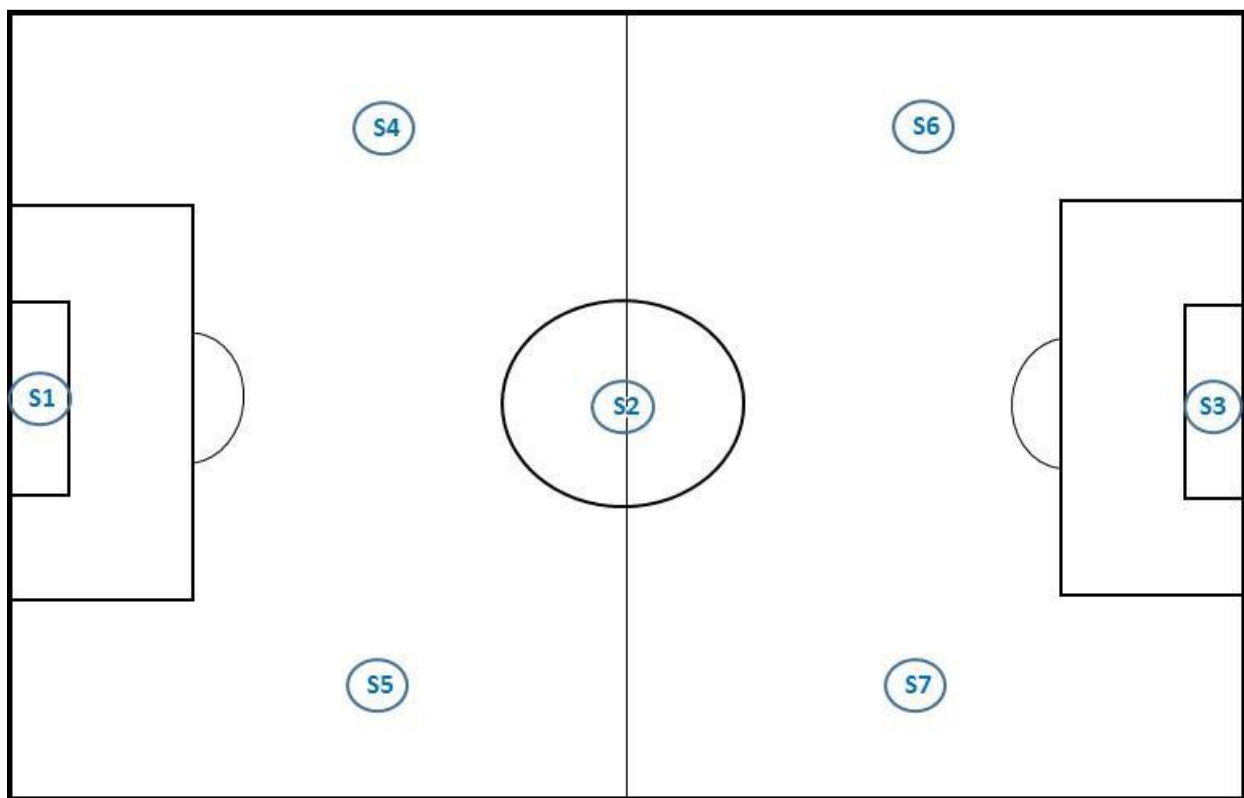
This study will only include artificial turf and ground surface installations within Washington State. Individual site boundaries will be documented in field notes or by reference to materials supplied by the site's facility or recreation manager. The sampling sites for each artificial turf installation will depend on the size and shape of the installation (see Figures 3 and 4). Each artificial turf or ground surface area will have seven sampling sites.

7.2 Field data collection

7.2.1 Sampling locations and frequency

Up to 30 artificial turf or ground cover installations will be included in this study. Installations sampled in the companion stormwater runoff study (Salamone 2025) will be sampled for component sampling. All sampling locations will have one sampling event. As much as possible, sampling events will take place during dry weather events.

Artificial turf maintenance activities and play on the athletic fields may cause the spreading of infill material and scattering of turf blades. Due to the potential variability in materials, component samples will be collected at seven locations from each artificial turf or ground cover area (Figures 2 and 3) (EPA ORD 2018). For unique installations that do not match Figures 3 or 4, seven dispersed sampling locations will be identified. To avoid removing too much material from a small area, each sample area will encompass one square meter (OEHHA 2025).



 = Sample Collection Locations

Figure 2. Example sample collection locations for rectangular-shaped installations (EPA ORD 2018).

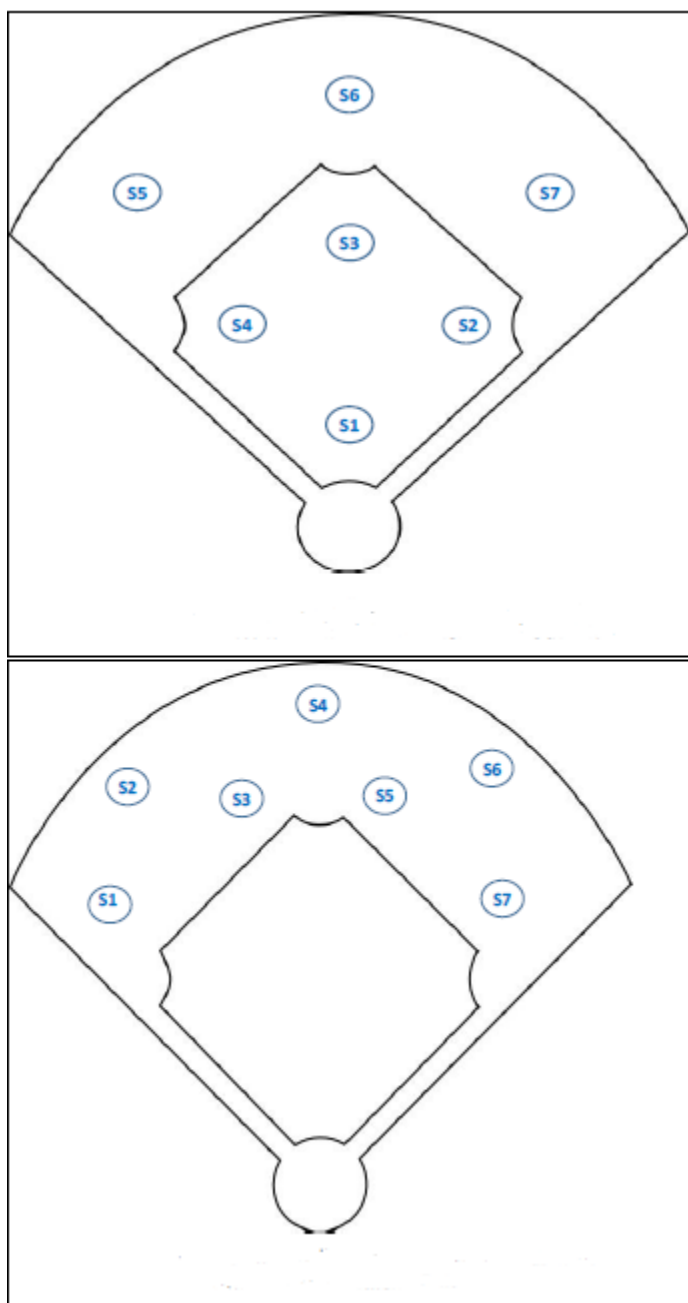


Figure 3. Example sample locations for diamond-shaped installations with and without artificial turf infields (EPA ORD 2018).

7.2.2 Field parameters and laboratory analytes to be measured

- Date and time of collection.
- Time (in hours or days) since the previous measurable rainfall event.
- Contributing land use to the field area, e.g., multiple artificial turf installations, playgrounds, parking lots.
- Presence and identification of any debris in the field.
- Colors of turf blades that are present on the field.

7.3 Modeling and analysis design

Not applicable to this study.

7.4 Assumptions underlying design

This study is designed to assess existing installations of artificial turf and ground cover components for 6PPDQ, PFAS, and metals. Many factors may influence the concentration of chemicals detected in installed artificial turf and ground cover components. Upon collection, components may contain chemicals from the manufacturing process, installation process, aging and weathering, contamination during use, and environmental contamination like air and rain deposition. Other environmental or contamination sources of 6PPDQ, PFAS, or metals cannot be determined in this study, and results are not intended to predict conditions at artificial installations not included in this study.

The impact of environmental factors on the release and transport of 6PPDQ, PFAS, and metals likely varies from one installation to another. It is thought that high temperatures may increase the release rate of 6PPDQ (Zhao et al. 2024), but the effects of temperature on the release of 6PPDQ and PFAS are not well understood. The optimal sampling time to capture the highest release of 6PPDQ, PFAS, or metals from artificial installations is not known.

Samples collected for this study are only representative of conditions at that point in time and cannot be assumed to represent the highest or lowest concentrations of 6PPDQ, PFAS, or metals that may be present in the components of artificial installations. Materials may not be homogeneous across all installations. Multiple sample locations from each artificial turf and ground cover installation will be sampled and composited together to reduce the variability of results.

7.5 Possible challenges and contingencies

7.5.1 Logistical problems

An agreement of participation must be obtained from site owners or representatives prior to sampling events. If participation is denied by any site owners or representatives for any reason

during the study, the site will be removed from the study. The study will commence with the remaining sites.

Samples will be shipped and/or couriered from Ecology headquarters to multiple laboratories for preparation and analysis. Shipping complications may delay analysis and add additional complexities to the chain of custody of the samples. Any shipping or chain of custody complications will be addressed in the final report.

7.5.2 Practical constraints

This project will sample artificial turf and ground surface installations across Washington State. Traveling from Ecology duty stations to artificial installations may be complicated by weather or traffic conditions. Travel for sample events will be planned to minimize risk.

7.5.3 Schedule limitations

Field sampling for this project is scheduled through December 31, 2025. Even with thorough planning, schedule limitations may arise due to the availability of the project assistant and artificial turf and ground cover installation representatives. Every effort will be made to sample during all scheduled events. If needed, sampling may be rescheduled until December 31, 2025.

8.0 Field Procedures

8.1 Invasive species evaluation

Not applicable to this study.

8.2 Measurement and sampling procedures

Field staff will follow safety procedures outlined in the EAP Safety Manual.

Sample collection design will be guided in part by the following:

- U.S. EPA's Office of Research and Development's (ORD) Tire Crumb Characterization Study: Field Collection SOP (EPA ORD 2018).
- California EPA's Office of Environmental Health Hazard Assessment's SOPs for Synthetic Turf Study Sample Collection, Preparation, and Analysis (OEHHA 2025).
- Literature review (EPA ORD 2009; Van Urlisch 2010; Lauria et al. 2022).

Due to a lack of widely used standardized field procedures for the collection of artificial turf and ground cover, additional procedures may be developed to meet the requirements of this study and are specified in the following sections.

To minimize PFAS cross-contamination and for guidance on PFAS-containing equipment and material to avoid while sampling and processing, staff will use the following sampling guidance developed by Michigan State's PFAS Action Response Team:

- PFAS Sampling Quick Reference Field Guide (EGLE 2018).
- General PFAS Sampling Guidance (EGLE 2024).

Sample processing will follow Ecology's SOP PTP001 Product Collection and Sample Processing (Ecology 2021a).

Sample storage will follow guidance from:

- SOP MEL 730140 Extraction of 6PPD-Quinone in Solids and SOP MEL 730136: Extraction Analysis of 6PPD-Quinone by EPA 1634
- Quality Assurance Project Plan: Monitoring of Tire Contaminants in Coho Salmon Watersheds (Smith 2023)
- SGS AXYS Method MLA-110: PFAS by 1633
- SOP PTP001: Product Collection and Sample Processing

8.2.1 Sampling procedures

For this study, artificial turf infill, turf blades, backing, and other artificial surface materials will be collected and analyzed for 6PPDQ, PFAS, and metals. If field owners have retained material,

we will request to sample those. If retained materials are not available, samples will be field collected. Field collection procedures for artificial turf and ground cover components have been developed using U.S. EPA ORD's SOP (EPA ORD 2018) and California EPA's OEHHA SOP (OEHHA 2025) as guidance.

Whenever possible, samples will be collected from artificial turf and ground cover installations during dry weather conditions.

All sample collection tools will be cleaned following SOP PTP001 Product Collection and Sample Processing (Ecology 2021a) prior to each sampling event.

Field staff must wear clean, powderless nitrile gloves during sample collection, handling sample containers, and handling sampling equipment. Gloves should always be changed between sampling events.

Only approved ballpoint pens or ultra-fine point Sharpie® markers may be used to label samples and write in field logs (EGLE 2018). Only non-waterproof and non-recycled paper may be used for field log forms.

As much as possible, field staff will wear PFAS-free field gear. Field staff will avoid wearing or using materials containing PFAS marketed as Teflon®, water-resistant treated clothing, and some personal care products (EGLE 2024). Field staff will refrain from handling or consuming pre-wrapped food or snacks before or during sampling events.

Upon arrival at each field site, seven subsampling locations will be identified following Figures 2 and 3 (EPA ORD 2018), as applicable. Due to the weight variation of different component materials and to ensure representativeness and consistency among samples, a mobile scale will be used to ensure approximately equal weights have been sampled at each location. Field staff will collect around 2.0 grams of each component at all seven subsample locations for a composited total of 14 grams of each component. The seven subsamples for each component type will be composited to ensure representativeness of the sample site. To avoid removing too much material from a small area, each subsample area will encompass one square meter (OEHHA 2025). A sampling square will be used to mark the boundary of each sampling area.

During field collection, all component samples will be collected into certified clean PFAS-free high-density polyethylene (HDPE) or polypropylene containers (EGLE 2018). While 6PPDQ is known to readily attach to many plastics while in aqueous solutions (Hu et al. 2023), not much is known about the ability of 6PPDQ to migrate from consumer products. Composite polyethylene containers can be used for temporary sample storage (Smith 2023).

Field HDPE sample bottles will be stored in a cooler and transported on ice to Ecology headquarters in Lacey, Washington. Upon arrival at Ecology headquarters, samples will be stored in the COC freezer until preparation. Samples will be brought to the product studies preparation room (OL-21) and sub-aliquoted into sample jars for long-term storage following the steps in SOP PTP001, and as stated in section 8.3. Samples for 6PPDQ and PFAS will remain in the HDPE container, and metals samples will be transferred to amber glass containers. Once samples have been prepared for storage, they will be put back into the COC room freezer (OL-

15) and will be stored frozen until submission to the labs. Sample information will be logged into the Consumer Product Database (CPD) following SOP PTP002.

8.2.2 Infill material sampling procedures

Stainless steel scoops will be used for the collection of infill samples (OEHHA 2025). Infill will be placed onto a Kim-wipe sheet and weighed on a mobile scale. The seven subsamples will be composited into a single certified clean PFAS-free high-density polyethylene (HDPE) bottle and will later be divided into individual sample jars as described in 8.2.1.

8.2.3 Turf blade sampling procedures

Turf blades will be collected by pulling loose blades, collecting broken blades, or cutting (EPA ORD 2009; Lauria et al 2022). Loose and broken blades will be collected using cleaned stainless-steel forceps. Turf blades will be cut using clean stainless-steel scissors. Any cutting of turf blades will be spread throughout the sample area to minimize damage. Blades will be placed onto a Kim-wipe and weighed on a mobile scale. The seven subsamples will be composited into a single certified clean PFAS-free high-density polyethylene (HDPE) bottle and will later be divided into individual sample jars as described in 8.2.1.

Some artificial turf installations have turf blades of multiple colors. The predominant color will be given priority for sampling for all fields. For 10% of fields, accent colors will also be collected and tested. Different color turf blades may contain different levels of chemicals and will be tested separately (Van Urlisch 2010). For secondary color turf blade sampling, locations will vary depending on the layout of the secondary colors. Seven sampling locations where the secondary turf color is accessible will be chosen at random. Any loose or broken turf blades of the secondary color that are within each of the seven sampling locations will be collected; otherwise, turf blades will be collected through cutting.

8.2.4 Backing, shock pad, or underlayment sampling procedures

To avoid damage to existing artificial turf and ground cover, overstock backing, shock pad, and/or underlayment materials will be requested from field owners. If overstock materials are not available, samples will not be taken from these components.

8.3 Containers, preservation methods, holding times

Table 10 outlines the sample containers, preservation methods, and established holding times that will be used for this study.

Sample bottles will be stored on ice packs during transportation from field sites to Ecology headquarters in Lacey, Washington. Upon arrival, samples will be stored in the COC freezer until sample preparation. For sample preparation, samples will be brought to the product testing preparation room, and prepared following the steps in SOP PTP001, and as follows:

- For metals, two (2) grams of each component sample will be measured into certified clean amber glass bottles.

- For 6PPDQ and PFAS samples, 10 grams of each component sample will be measured into new certified clean and PFAS-free amber HDPE or polypropylene bottles.
- All samples will be stored in a -20°C freezer in Ecology's headquarters facility COC room.
- Any remaining composited components will be saved as archives in labeled field collection containers and stored at -20°C at Ecology's headquarters facility.

Once all field samples have been collected and processed, samples will be transported with ice packs via courier to MEL and overnight to the contract lab.

Table 10. Sample containers, preservation, and holding times.

Parameter	Matrix	Minimum Quantity Required	Field Collection Container	Sample Container	Preservative	Holding Time
6PPDQ	Plastic, rubber, plant-based materials	5 grams	Certified clean 500 ml PFAS-free HDPE	Certified clean 500 ml PFAS-free HDPE bottle with linerless HDPE or polypropylene caps	-20°C	1 year
PFAS (40 compounds)	Plastic, rubber, plant-based materials	5 grams	Certified clean 500 ml PFAS-free HDPE	Certified clean 500 ml PFAS-free HDPE bottle with linerless HDPE or polypropylene caps	-20°C	1 year
Metals (6 elements)	Plastic, rubber, plant-based materials	2 grams	Certified clean 500 ml PFAS-free HDPE	Certified clean 250ml large-mouthed amber glass jar with linerless HDPE or polypropylene caps	-20°C	1 year

HDPE: high-density polyethylene

PFAS: per- and polyfluoroalkyl substances

8.4 Equipment decontamination

Equipment decontamination between sampling events will follow Ecology's SOP EAP090, Decontaminating Field Sampling Equipment for Sampling Toxics in the Environment (Ecology 2021b).

8.5 Sample ID

Field locations will be assigned IDs based on their regional study area of Washington (Figure 1). For example, in each region, Northwest Region (NWR), Southwest Region (SWR), Central Region (CR), and Eastern Region (ER), the first field location will be labeled as "1", the second field location as "2", and so on. Therefore, "NWR-1-1" is the first field location sampled from the Northwest Region of Washington, "NWR-2-1" is the second field location sampled, and so on. "NWR-1-1-1" is the first component sample from the first field location sampled from the Northwest Region of Washington.

Samples will be assigned laboratory IDs based on the work order number assigned by MEL.

8.6 Chain of custody

Chain of custody will be maintained for all samples throughout the project. Samples will be stored in a freezer in the Ecology headquarters locked chain of custody room or within the locked product testing preparation room. This study will use the MEL chain of custody form for field collection and submission of samples to MEL and the contract laboratory.

The contract laboratory will maintain a chain of custody record, including custody acceptance at, and release from, the sample preparation (cryomilling) laboratory and analytical laboratory locations. A copy of shipping records must be provided along with the chain of custody records.

8.7 Field log requirements

A field log will be maintained for all sampling events (see section 7.2.2).

Field staff should use only approved PFAS-free permanent ink pens for all entries (see section 8.2.1). Staff should make corrections with single line strikethroughs, initial and date corrections, and not use any type of correction fluid or tape.

8.8 Other activities

Not applicable to this study.

9.0 Laboratory Procedures

9.1 Lab procedures table

Table 11 outlines the laboratory procedures that will be used for this study.

Table 11. Measurement methods (laboratory).

Analyte	Sample Matrix	Number of Field Samples [±]	Expected Range of Results	LLOQ/MRL	Sample Prep Method	Analytical (Instrumental) Method
6PPDQ	Plastic, rubber, plant-based materials	≥66	Unknown	2.5 µg/Kg	MEL SOP 730140	MEL SOP 730140
PFAS (40 compounds)	Plastic, rubber, plant-based materials	≥66	Unknown	0.08-10.04 ng/g	EPA 1633*	EPA 1633*
Metals (6 elements)	Plastic, rubber, plant-based materials	≥66	Unknown	10 mg/kg	EPA 3052	EPA 6020B

LLOQ/MRL : lower limit of quantitation/method reporting limit

PFAS: per- and polyfluoroalkyl substances

SOP: standard operating procedure

MEL: Manchester Environmental Lab

EPA: Environmental Protection Agency

[±]Number of field samples does not include quality control samples.

*Both EPA 1633 and EPA 1633A are acceptable methods.

9.2 Sample preparation method(s)

Sample preparation methods for each analyte are given in Table 10. All PFAS and 6PPDQ samples will be cryomilled at a contract laboratory. After cryomilling, the PFAS samples will be analyzed by the contract laboratory, and 6PPDQ samples will be sent to MEL for analysis. Preparation blanks for the cryomilling preparation will be collected following the lab's cleaning protocol at the beginning and end of each processing day. Blanks will consist of rinsate from one cryomill vessel. Rinsate will consist of at least 500 ml of methanol, and each rinsate sample

will be split in half, with half of the rinsate blanks sent to MEL for analysis of 6PPDQ contamination, and half analyzed at the contract lab for PFAS contamination.

Cryomilling results in fine, uniform particle sizes, allowing for more efficient solvent penetration during extraction by maximizing the surface area of the sample. Improved solvent penetration and analyte recoverability can be especially critical for complex matrices like consumer products. Solvent extraction without cryomilling may only capture chemicals on the surface of a solid sample. While preparation methods for consumer products have not gone through many side by side comparison studies, cryomilling preparation supports increased and consistent recoverability of solvent-extracted analytes within solid plant and tissue samples (Lolo et al. 2007; Riter et al 2014). Cryomilling is also a commonly used preparation method for consumer products in laboratories that specialize in consumer product testing (EPA and CDC 2019; 3M n.d.).

9.3 Special method requirements

Not applicable to this study.

9.4 Laboratories accredited for methods

MEL is accredited to perform analysis of selected metals by EPA 6020B.

An accredited contract laboratory will analyze product component samples by EPA Method 1633 for 40 PFAS compounds for this study. MEL is currently seeking accreditation for EPA Method 1633. If MEL has received accreditation for Method 1633 prior to submission of samples, MEL may conduct analysis. If no accredited laboratory is available, a waiver for the use of an unaccredited method will be requested for this study.

MEL is currently seeking accreditation for 6PPDQ analysis in solids. There are currently no laboratories accredited to perform 6PPDQ analysis in solid matrices. An SOP has been submitted to the Laboratory Accreditation Unit for review. Given the possibility that accreditation may not be achieved in time for the proposed study schedule, we will request a waiver to use an unaccredited method for this study.

10.0 Quality Control Procedures

10.1 Table of field and laboratory quality control

Table 12 presents the quality control (QC) sample types and frequency for this study.

Samples from this study may be analyzed alongside other samples of the same matrix within the same batch of 20 or fewer samples.

Table 12. Quality control samples, types and frequency.

Parameter	Field Replicates	Lab Duplicates	Laboratory Control Standards	Laboratory Method Blanks	Laboratory Matrix Spikes	Surrogate Standards
6PPDQ	10% of samples	1 per batch	1 OPR per batch	1 per batch	NA	all samples
PFAS (40 compounds)	10% of samples	1 per batch	1 OPR/LLOPR per batch	1 per batch	NA	all samples
Metals (6 elements)	10% of samples	1 per batch	1 LCS/LCSD per batch	1 per batch	1 MS/MSD per batch	NA

Batch: 20 or fewer samples which are analyzed together

LCS: laboratory control sample

LCSD: laboratory control sample duplicate

LLOPR: low-level ongoing precision and recovery

MS: matrix spike

MSD: matrix spike duplicate

OPR: ongoing precision and recovery

PFAS: per- and polyfluoroalkyl substances

10.2 Corrective action processes

When laboratory QC criteria are not met, laboratories are to take appropriate corrective actions and discuss those actions in the case narrative. Deviations from accredited laboratory methods, deviations from the required corrective actions, or data that do not meet laboratory QC criteria will be documented by the laboratory analyst and communicated to the principal investigator. The project manager or principal investigator will determine the best course of action, which may include recollecting and resubmitting the samples. If correction actions are not available, the data may be qualified or rejected.

An assessment of data quality will be provided in the final report. Any departures from this QAPP will be documented in the final report.

11.0 Data Management Procedures

11.1 Data recording and reporting requirements

Laboratory data will be received electronically as an electronic data deliverable (EDD) or comparable package. The project manager or principal investigator will perform a final quality assurance (QA) review of all data before they are uploaded into the Consumer Product Database (CPD).

Study data will be stored in Ecology's CPD according to SOP PTP002 (Ecology 2022b). The project assistant is responsible for uploading and publishing data to the CPD, and the project manager or principal investigator is responsible for data QA verification in the CPD (see section 13.2).

11.2 Laboratory data package requirements

For contract laboratory data, a Level 4 data package per EPA National Functional Guidelines will be required for all data, and a Stage 4 validation will be conducted. For MEL data, all required content for data validation must be provided to the data validator. A Stage 3 data validation will be required for metals, and a Stage 4 validation will be required for 6PPDQ samples. The lab data will contain all required specific content, along with sample and QC data. The data package must include all sample raw data, QA/QC sample raw data, and chain of custody forms needed to perform independent verification of the results and sample handling procedures.

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.

MEL's Data Validator will review and verify that all data packages are complete and in accordance with the Statement of Work and project QAPP.

11.3 Electronic transfer requirements

Laboratory case narratives and data packages will be transferred electronically in PDF format and EDDs, respectively. EDDs will be in a .csv or .xlsx spreadsheet format that meets Ecology's standard PTDB formatting requirements.

11.4 Consumer Product Database data upload procedures

The laboratory data for this project will be stored in Ecology's Consumer Product Database according to SOP PTP002 (Ecology 2022b).

11.5 Model information management

Not applicable to this study.

12.0 Audits and Reports

12.1 Field, laboratory, and other audits

No defined audit exists for the fieldwork in this study.

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

12.2 Responsible personnel

Laboratory audits are conducted by Ecology's Laboratory Accreditation Unit.

12.3 Frequency and distribution of reports

A final published report summarizing the data and findings will be published after the study is completed.

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 principal investigator 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 principal investigator and project assistant will review field logs for completeness and clarity.

13.2 Laboratory data verification

Lab data verification is the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. MEL will include a case narrative that discusses whether (1) MQOs were 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. The case narrative will also define data qualifiers and the reason for their use and will be released to the project manager.

The principal investigator will review data packages and data quality reports and conduct a verification review of the data to assess suitability. The principal investigator, 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.

Study data will be stored in Ecology's CPD according to SOP PTP002 (Ecology 2022b).

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. All required content for data validation must be provided to the data validator.

A stage 4 data validation for PFAS and 6PPDQ analyses will be completed using the technical specifications outlined in MEL SOP 770046 Data Validation of Analytical PFAS Data (Ecology 2024) and QAPP-specific MQOs. A stage 3 data validation will be completed on metals analyses using National Functional Guidelines for Inorganic Superfund Methods Data Review (EPA 2020) or equivalent, and QAPP-specific MQOs.

13.4 Model quality assessment

Not applicable to this study.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining 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 QAPP-specific MQOs were met. If all MQOs and QC criteria are met, the data quality will be considered suitable for meeting study objectives. The final report for this study will discuss the data quality findings.

14.2 Treatment of non-detects

For PFAS analyses, laboratory data will be reported down to the method detection limit from Table 7. For 6PPDQ analyses, laboratory data will be reported to the limit of quantitation (LOQ). For metals analyses, laboratory data will be reported to the lower limit of quantitation (LLOQ). An associated “U” (analyte not detected above the method reporting limit) or “UJ” (analyte not detected above an estimated value method reporting limit) qualifier will be assigned to those samples.

For PFAS identification, laboratory results flagged due to identification failures will be qualified “NJ” (evidence that the analyte is present but does not meet identification criteria; the result is an estimate), accepted as detected, and included in total PFAS calculations.

All samples will be evaluated against the associated method, equipment, and cryomill preparation blanks for each analytical or cryomill preparation batch. Sample results less than or equal to 5x the method, equipment, and cryomill preparation blank concentration will be qualified as non-detect due to lab background or contamination. Total PFAS calculations will only include detected results.

14.3 Data analysis and presentation methods

Total (analyzed) PFAS, individual PFAS, 6PPDQ, and individual metals analyte concentrations will be presented by location codes, events, and regions. 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.

14.4 Sampling design evaluation

The number and type of samples outlined in this QAPP were designed to meet the objectives of this study.

14.5 Documentation of assessment

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

15.0 References

- 3M. n.d. 3M™ Dynamar™ Polymer Processing Additives (PPA) Product Comparison Guide. Accessed May 7, 2025.
<https://multimedia.3m.com/mws/media/1027184O/3m-dynamar-ppas-product-comparison-guide.pdf>
- Bauer, B., K. Egebaek, and A.K. Aare. 2017. Environmentally friendly substitute products for rubber granulates as infill for artificial turf fields. Report M-955. Oslo, Norway: Norwegian Environmental Agency.
<https://www.miljodirektoratet.no/globalassets/publikasjoner/M955/M955.pdf>
- Bertling, J., B. Dresen, R. Bertling, V. Aryan, and T. Weber. 2021. Artificial turf pitches — System analysis for Switzerland and Germany taking into account micro-plastic and greenhouse gas emissions, recycling, locations and standards, costs, and player opinions. Oberhausen, Fraunhofer UMSICHT.
<https://www.researchgate.net/publication/355652417>
- Bocca, B., G. Forte, F. Petrucci, S. Costantini, and P. Izzo. 2008. Metals contained and leached from rubber granulates used in synthetic turf areas. *Science of the Total Environment* 407:2183-2190.
<http://dx.doi.org/10.1016/j.scitotenv.2008.12.026>
- Buck, R.C., J. Franklin, U. Berger, J.M. Conder, I.T. Cousins, P. de Voogt, et al. 2011. Perfluoroalkyl and polyfluoroalkyl substances in the environment: Terminology, classification, and origins. *Integrated Environmental Assessment and Management* 7(4):513-541.
<https://doi.org/10.1002/ieam.258>
- Cao, G., W. Wang, J. Zhang, P. Wu, X. Zhao, Z. Yang, D. Hu, Z. Cai. New Evidence of Rubber-Derived Quinones in Water, Air and Soil. *Environmental Science & Technology* 56 (7): 4142-4150. DOI: 10.1021/acs.est.1c07376
- Cheng, H., Y. Hu, and M. Reinhard. 2014. Environmental and health impacts of artificial turf: A review. *Environmental Science and Technology* 48:2114-2129.
<https://pubmed.ncbi.nlm.nih.gov/24467230/>
- CPSC [United States Consumer Product Safety Commission]. 2008. CPSC Staff Analysis and Assessment of Synthetic Turf “Grass Blades”.
<https://www.cpsc.gov/s3fs-public/pdfs/turfassessment.pdf>
- Deng, C., J. Huang, Y. Qi, D. Chen, W. Huang. 2022. Distribution patterns of rubber tire-related chemicals with particle size in road and indoor parking lot dust. *Science of The Total Environment* 844.
<https://doi.org/10.1016/j.scitotenv.2022.157144>

- Dinglasan, M.J., Y. Ye, E.A. Edwards, and S.A. Mabury. 2004. Fluorotelomer alcohol biodegradation yields poly- and perfluorinated acids. *Environmental Science and Technology* 38(10):2857-2864.
<https://pubs.acs.org/doi/full/10.1021/es0350177>
- DTSC [Department of Toxic Substances Control]. 2022. Product – Chemical Profile for Motor Vehicle Tires Containing N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD). California Environmental Protection Agency.
https://dtsc.ca.gov/wp-content/uploads/sites/31/2022/05/6PPD-in-Tires-Priority-Product-Profile_FINAL-VERSION_accessible.pdf
- DTSC [Department of Toxic Substances Control]. 2024. Background Document on Candidate Chemicals in Artificial Turf. California Environmental Protection Agency.
<https://dtsc.ca.gov/wp-content/uploads/sites/31/2024/07/Background-Document-on-Candidate-Chemicals-in-Artificial-Turf.pdf>
- Ecology [Washington State Department of Ecology] and King County [King County Department of Natural Resources]. 2011. Control of Toxic Chemicals in Puget Sound: Assessment of Selected Toxic Chemicals in the Puget Sound Basin, 2007-2011. Publication 11-03-055. Olympia, WA.
<https://apps.ecology.wa.gov/publications/SummaryPages/1103055.html>
- Ecology [Washington State Department of Ecology]. 2023. Standard Operating Procedure PTP001, Version 2.2: Product Collection and Sample Processing. Olympia, WA. For a copy of this document, please submit a request by visiting ecology.wa.gov/publicrecords.
- Ecology [Washington State Department of Ecology]. 2021b [Recertified 2020]. Standard Operating Procedure EAP090 Decontaminating Field Equipment for Sampling Toxics in the Environment. Publication 21-03-202. Olympia, WA.
<https://apps.ecology.wa.gov/publications/SummaryPages/2103202.html>
- Ecology [Washington State Department of Ecology]. 2022a. 6PPD in Road Runoff: Assessment and Mitigation Strategies. Publication 22-03-020. Olympia, WA.
<https://apps.ecology.wa.gov/publications/SummaryPages/2203020.html>
- Ecology [Washington State Department of Ecology]. 2025. Standard Operating Procedure PTP002, Version 3.0: Database Entry and Quality Assurance. Olympia, WA. For a copy of this document, please submit a request by visiting ecology.wa.gov/publicrecords.
- Ecology [Washington State Department of Ecology]. 2024. Programmatic Quality Assurance Project Plan: Statewide PFAS Preliminary Assessments. Publication 2403101. Washington State Department of Ecology, Olympia.
<https://apps.ecology.wa.gov/publications/SummaryPages/2403101.html>.

- Ecology [Washington State Department of Ecology]. 2024. Standard Operating Procedure MEL770046, Version 1.0: Data Validation of EPA Method 1633 PFAS Analytical Data. Port Orchard, WA. For a copy of this document, please submit a request by visiting ecology.wa.gov/publicrecords.
- EGLE [Michigan Department of Environment, Great Lakes, and Energy]. 2018. PFAS Sampling Quick Reference Field Guide. Michigan PFAS Action Response Team. Lansing, MI. <https://www.michigan.gov/pfasresponse/-/media/Project/Websites/PFAS-Response/Sampling-Guidance/Quick-Reference-Field-Guide.pdf?rev=9aab74b786684de6b54319d651e85d09>
- EGLE [Michigan Department of Environment, Great Lakes, and Energy]. 2024. General PFAS Sampling Guidance. Michigan PFAS Action Response Team. Lansing, MI. <https://www.michigan.gov/pfasresponse/-/media/Project/Websites/PFAS-Response/Sampling-Guidance/General.pdf?rev=6217442052bf4fedb89bbf786560d645>
- Emon, F.J., M.F. Rohani, N. Sumaiya, M.F. Tuj Jannat, Y. Akter, M. Shahjahan, et. al. 2023. Bioaccumulation and Bioremediation of Heavy Metals in Fishes-A Review. *Toxics* 11(6): 510. <https://www.mdpi.com/2305-6304/11/6/510>
- EPA [U.S. Environmental Protection Agency] and CDC [U.S. Centers for Disease Control and Prevention]. 2019. Synthetic turf field recycled tire crumb rubber research under the federal research action plan. Final report part 1- Tire crumb rubber characterization volume 1. Publication Number EPA 600-R-19-051.1. Washington, DC. <https://www.epa.gov/chemical-research/july-2019-report-tire-crumb-rubber-characterization-0>
- EPA [U.S. Environmental Protection Agency]. 2020. National Functional Guidelines for Inorganic Superfund Methods Data Review. Office of Superfund Remediation and Technology Innovation, Washington, DC. Publication Number EPA-542-R-20-006f. <https://www.epa.gov/clp/superfund-clp-national-functional-guidelines-data-review>
- EPA ORD [U.S. Environmental Protection Agency, Office of Research and Development]. 2009. A Scoping-Level Field Monitoring Study of Synthetic Turf Fields and Playgrounds. Publication Number EPA/600/R-09/135. https://cfpub.epa.gov/si/si_public_record_report.cfm?LAB=NERL&dirEntryID=215113
- EPA ORD [U.S. Environmental Protection Agency, Office of Research and Development]. 2018. Tire Crumb Characterization Study: Field Collection and Laboratory Standard Operating Procedures (SOPS). Publication Number EPA/600/R-18/238. [Tire Crumb Characterization Study: Field Collection and Laboratory Standard Operating Procedures \(SOPS\) | Science Inventory | US EPA](#)

- Ferreira, T., V. Homem, F. Cereceda-Balic, X. Fadic, A. Alves, and N. Ratola. 2024. Are volatile methylsiloxanes in downcycled tire microplastics? Levels and human exposure estimation in synthetic turf football fields. *Environmental Science and Pollution Research* 31:11950-11967.
<https://link.springer.com/article/10.1007/s11356-024-31832-1>
- Glüge, J., M. Scheringer, I.T. Cousins, J.C. DeWitt, G. Goldenman, D. Herzke, et al. 2020. An overview of the uses of per- and polyfluoroalkyl substances (PFAS). *Environmental Science: Processes & Impacts* 22(12):2345-73.
<https://pubs.rsc.org/en/content/articlehtml/2020/em/d0em00291g>
- Gomes, F.O., M. R. Rocha, A. Alves, and N. Ratola. 2021. A review of potentially harmful chemicals in crumb rubber used in synthetic football pitches. *Journal of Hazardous Materials* 409:124998.
<https://www.sciencedirect.com/science/article/abs/pii/S0304389420329897>
- Goodrow, S. 2023. Technical Memorandum: PFAS In Artificial Turf. New Jersey Department of Environmental Protection.
<https://dep.nj.gov/wp-content/uploads/dsr/pfas-artificial-turf-memo-2023.pdf>
- Huang, W.; Y. Shi; J. Huang; C. Deng; S. Tang; X. Liu; D. Chen. 2021. Occurrence of Substituted p-Phenylenediamine Antioxidants in Dusts. *Environmental Science & Technology Letters*. 8 (5): 381-385.
- Hu, X., H., N. Zhao, Z. Tian, K. Peter, M.C. Dodd, and E.P. Kolodziej. 2023. Chemical characteristics, leaching, and stability of the ubiquitous tire rubber-derived toxicant 6PPD-quinone. *Environmental Science: Processes and Impacts* 5:901-911.
<https://pubs.rsc.org/en/content/articlelanding/2023/em/d3em00047h/unauth>
- Ihenetu, S.C., Q. Xu, L. Fang, M. Azeem, G. Li, C.E. Enyoh. 2025. 6PPD and 6PPD-Quinone in the Urban Environment: Assessing Exposure Pathways and Human Health Risks. *Urban Science*. 9, 228.
<https://doi.org/10.3390/urbansci9060228>
- Jastifer, J.R., A.S. McNitt, C.D. Mack, R.W. Kent, and K.A. McCullough. 2019. Synthetic Turf: History, Design, Maintenance, and Athlete Safety. *Sports Health* 11(1):84-90.
<https://pubmed.ncbi.nlm.nih.gov/30096021/>
- Kole, P.J., F.G.A.J. Van Belleghem, J.J. Stoorvogel, A.M.J. Ragas, and A. Löhr. 2023. Tyre granulate on the loose; How much escapes the turf? A systematic literature review. *Science of The Total Environment* 903:166221.
<https://doi.org/10.1016/j.scitotenv.2023.166221>
- Kruger, O., U. Kalbe, W. Berger, K. Nordhaub, G. Christoph, and H.P. Walzel. 2012. Comparison of Batch and Column Tests for the Elution of Artificial Turf System Components. *Environmental Science and Technology* 46:13085-13092.
<http://dx.doi.org/10.1021/es301227y>

- Lambert, Y.J., and D.A.M. Plume. 2008. Polyethylene Composition for Artificial Turf. U.S. Patent Number 0090955A1. U.S. Patent and Trademark Office.
- Lauria, M.Z., A. Naim, M. Plassmann, J. Fäldt, R. Sühning, and J.P. Benskin. 2022. Widespread occurrence of non-extractable fluorine in artificial turfs from Stockholm, Sweden. *Environmental Science and Technology Letters* 9(8):666-72.
<https://pubs.acs.org/doi/pdf/10.1021/acs.estlett.2c00260>
- Li, X., M. Berger, C. Musante, and M.J.I. Mattina. 2010. Characterization of substances released from crumb rubber material used on artificial turf fields. *Chemosphere* 80:279-285.
<https://www.sciencedirect.com/science/article/abs/pii/S0045653510004285?via%3Dihub>
- Lohmann, R., I. Cousins, J. Dewitt, J. Glüge, G. Goldenman, D. Herzke, A. Lindstrom, M. Miller, C. Ng, S. Patton, M. Scheringer, X. Trier, Z. Wang. 2020. Are fluoropolymers really of low concern for human and environmental health and separate from other PFAS? *Environmental Science Technology*. 54(20):12820–12828.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC7700770/#R2>
- Marsili, L., D. Coppola, N. Bianchi, S. Maltese, M. Bianchi, and M.C. Fossi. 2014. Release of Polycyclic Aromatic Hydrocarbons and Heavy Metals from Rubber Crumb in Synthetic Turf Fields: Preliminary Hazard Assessment for Athletes. *Environmental & Analytical Toxicology* 5(2):265.
<https://www.researchgate.net/profile/Letizia-Marsili/publication/275581397.pdf>
- Massey, R., L. Pollard, M. Jacobs, J. Onasch, and H. Harari. 2020. Artificial Turf Infill: A Comparative Assessment of Chemical Contents. *New Solutions: A Journal of Environmental and Occupational Health Policy* 30(1):10-26.
<https://journals.sagepub.com/doi/full/10.1177/1048291120906206>
- McMinn, M.H., X. Hu, K. Poisson, P. Berger, P. Pimentel, X. Zhang, P. Ashara, E.L. Greenfield, J. Eig, Z. Tian. 2024. Emerging investigator series: in-depth chemical profiling of tire and artificial turf crumb rubber: aging, transformation products and transport pathways. *Environmental Science: Processes and Impacts* 26:1703-1715.
<https://doi.org/10.1039/D4EM00326H>
- Menichini, E., V. Abate, L. Attias, S. De Luca, A. di Domenico, I. Fochi, et al. 2011. Artificial turf playing fields: Contents of metals, PAHs, PCBs, PCDDs and PCDFs, inhalation exposure to PAHs and related to preliminary risk assessment. *Science of the Total Environment* 409:4950-4957.
<https://www.sciencedirect.com/science/article/abs/pii/S0048969711007601>
- Murphy, M. and G.R. Warner. 2022. Health Impacts of Artificial Turf: Toxicity Studies, Challenges, and Future Directions. *Environmental Pollution* 310:119841.
<https://pubmed.ncbi.nlm.nih.gov/35948114/>

- OEHHA [Office of Environmental Health Hazard Assessment] California Environmental Protection Agency. 2025. SOPs for Sample Collection, Preparation, and Analysis Synthetic Turf Study. Appendix D.
<https://oehha.ca.gov/sites/default/files/media/2025-03/TurfAppendixd031325.pdf>
- OFM [Washington State Office of Financial Management]. 2024. April 1, 2024 Population of Cities, Towns, and Counties Used for Allocation of Selected State Revenues. Olympia, WA.
https://ofm.wa.gov/sites/default/files/public/dataresearch/pop/april1/ofm_april1_population_final.pdf
- Pavilonis, B.T., C.P. Weisel, B. Buckley, and P.J. Lioy. 2014. Bio-accessibility and Risk of Exposure to Metals and SVOCs in Artificial Turf Field Fill Materials and Fibers. *Risk Analysis* 34(1):44-55.
<https://onlinelibrary.wiley.com/doi/10.1111/risa.12081>
- Penta Group. 2022. Synthetic Turf and Crumb Rubber Infill Policy Landscapes. Presented at CalRecycle Virtual Technical Training Series 2.0. March 29-30 2022. Recycled Rubber Coalition. Sacramento, CA.
- Pfotenhauer, D., E. Sellers, M. Olson, K. Praedel, and M. Shafer. 2022. PFAS concentrations and deposition in precipitation: An intensive 5-month study at National Atmospheric Deposition Program – National trends sites (NADP-NTN) across Wisconsin, USA. *Atmospheric Environment*, 291(15).
- Reddick, R.S. 2012. Filler for Artificial Turf System. U.S. Patent Number 8263203B2. U.S. Patent and Trademark Office.
- Sherman, A. T. Masset, L. Wimmer, L.A. Dailey, T. Hüffera, F. Breider, T. Hofmann. 2025. The Invisible Footprint of Climbing Shoes: High Exposure to Rubber Additives in Indoor Facilities. *ACS EST Air*. 2: 930-942.
<https://pubs.acs.org/doi/10.1021/acsestair.5c00017>
- Salamone, Amy. 2025. Quality Assurance Project Plan: Toxic Chemicals in Stormwater Runoff From Artificial Turf Installations. Publication 24-03-108. Washington State Department of Ecology, Olympia.
<https://apps.ecology.wa.gov/publications/SummaryPages/2403108.html>.
- Smith, R. 2023. Quality Assurance Project Plan: Monitoring of Tire Contaminants in Coho Salmon Watersheds. Publication 23-03-113. Washington State Department of Ecology, Olympia.
<https://apps.ecology.wa.gov/publications/SummaryPages/2303113.html>.
- STC [Synthetic Turf Council]. 2020. Synthetic Turf Council Releases 2020 Synthetic Turf Market Report for North America.
<https://www.syntheticurfCouncil.org/news/512350/Synthetic-Turf-Council-STC-Releases2020-Synthetic-Turf-Market-Report-for-North-America.htm>

- Tian, Z., H. Zhao, K.T. Peter, M. Gonzales, J. Wetzel, C. Wu, et al. 2021. A ubiquitous tire rubber derived chemical induces acute mortality in coho salmon. *Science* 371(6525):185-189.
<https://www.science.org/doi/full/10.1126/science.abd6951>
- Tchounwou PB, C.G. Yedjou, A.K. Patlolla, D.J. Sutton. 2012. Heavy metal toxicity and the environment. *Exp Suppl.* 101:133-64.
<https://pubmed.ncbi.nlm.nih.gov/22945569/> TURI [Massachusetts Toxics Use Reduction Institute]. 2020. Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf Carpet. Lowell, MA.
<https://www.turi.org/publications/per-and-poly-fluoroalkyl-substances-pfas-in-artificial-turf-carpet/>
- Van Ulirsch, G., K. Gleason, S. Gerstenberger, D.B. Moffett, G. Pulliam, T. Ahmed, et. al. 2010. Evaluating and regulating lead in synthetic turf. *Environmental Health Perspectives* 118(10):1345-9.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC2957910/#sec7>
- Vineyard, M.F., S.M. LaBrake, S. Chalise, M.L. Clark, S.T. Conlan, and Z.H. Porat. 2018. PIXE Analysis of Artificial Turf. *Environment and Ecology Research* 6(1):60-65.
https://minerva.union.edu/vineyard/research/turf_paper.pdf
- Wallington, T.J., M.D. Hurley, J. Xia, D.J. Wuebbles, S. Sillman, A. Ito, et. al. 2006. Formation of C₇F₁₅COOH (PFOA) and Other Perfluorocarboxylic Acids during the Atmospheric Oxidation of 8:2 Fluorotelomer Alcohol. *Environmental Science and Technology* 40(3):924-930.
<https://pubs.acs.org/doi/full/10.1021/es051858x>
- Wu, Q. 2020. Thermoplastic Cellulosic Fiber Granules Useful as Infill Materials for Artificial Turf. U.S. Patent Number 10822752B2. U.S. Patent and Trademark Office.
- Zhang, X., Y. Wang, J. Liu, Y. Jiang, Y. Tian, and Z. Zhang. 2021. Distribution and Health Risk Assessment of Some Trace Elements in Runoff from Different Types of Athletic Fields. *Journal of Chemistry* 2021:5587057.
<https://doi.org/10.1155/2021/5587057>
- Zhao, F., J. Yao, X. Liu, M. Deng, X. Chen, C. Shi, et al. 2024. Occurrence and Oxidation Kinetics of Antioxidant p-Phenylenediamines and Their Quinones in Recycled Rubber Particles from Artificial Turf. *Environmental Science and Technology Letters* 11(4):335-341.
<https://pubs.acs.org/doi/abs/10.1021/acs.estlett.3c00948>
- Zhao, H.N., X. Hu, M. Gonzales, C.A. Rideout, G.C. Hobby, M.F. Fisher, et al. 2023. Screening p-Phenylenediamine antioxidants, their transformation products, and industrial chemical additives in crumb rubber and elastomeric consumer products. *Environmental Science and Technology* 57(7):2779-2791.
<https://pubs.acs.org/doi/full/10.1021/acs.est.2c07014>

Zuccaro, P., J. Licato, E.A. Davidson, D.C. Thompson, and V. Vasiliou. 2023. Assessing extraction-analysis methodology to detect fluorotelomer alcohols (FTOH), a class of perfluoroalkyl and polyfluoroalkyl substances (PFAS), in artificial turf fibers and crumb rubber infill. *Case Studies in Chemical and Environmental Engineering* 7:100280.
<https://www.sciencedirect.com/science/article/pii/S2666016422001025>

16.0 Appendices

Appendix A. Glossaries, Acronyms, and Abbreviations

Acronyms and Abbreviations

CAP	Chemical Action Plan
CAS RN	Chemical Abstracts Services Registry Number
CDC	U.S. Centers for Disease Control
COC	chain of custody
CPD	Consumer Products Database
CPSC	U.S. Consumer Product Safety Commission
DQO	data quality objective
DTSC	California's Department of Toxic Substances Control
EAP	Ecology's Environmental Assessment Program
e.g.	for example
Ecology	Washington State Department of Ecology
EGLE	Michigan's Environment, Great Lake and Energy
EPA	U.S. Environmental Protection Agency
et al.	and others
HDPE	high-density polyethylene
HWTR	Ecology's Hazardous Waste and Toxics Reduction
i.e.	in other words
LCS	laboratory control standard
LCSD	laboratory control standard duplicate
LLOPR	low-level ongoing precision and recovery
LLOQ	lower limit of quantitation
MDL	method detection limit
MEL	Manchester Environmental Laboratory
MQO	measurement quality objective
MRL	method reporting limit
MS	matrix spike

MSD	matrix spike duplicate
OEHHA	Office of Environmental Health Hazard Assessment
OPR	ongoing precision and recovery
ORD	Office of Research and Development
PBT	persistent bioaccumulative toxins
PFAS	per-and polyfluoroalkyl substances
PRP	Ecology's Product Replacement Program
PTFE	polytetrafluoroethylene
QAPP	quality assurance project plan
QA	quality assurance
QC	quality control
RCW	Revised Code of Washington
RPD	relative percent difference
RSD	relative standard deviation
SOP	standard operating procedures
WAC	Washington Administrative Code

Units of Measurement

mg/kg	milligrams per kilogram (parts per million)
ml	milliliter
ng/g	nanogram per gram (parts per billion)
µg/kg	micrograms per kilogram (parts per billion)
ppb	parts per billion
ppm	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 2025).

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

Ecology [Washington State Department of Ecology]. 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. Ecology, Olympia, WA.
<https://apps.ecology.wa.gov/publications/SummaryPages/0403030.html>

Federal Register. 2025. Appendix B to Part 136, Title 40—Definition and Procedure for the Determination of the Method Detection Limit—Revision 2 [1/5/2025]. Code of Federal Regulations, Federal Register. Washington DC.
<https://www.ecfr.gov/current/title-40/part-136/appendix-Appendix%20B%20to%20Part%20136>

Kammin, B. 2010. Definition developed or extensively edited by William Kammin, 2010. Washington State Department of Ecology, Olympia, WA.

USEPA [U.S. Environmental Protection Agency]. 1997. Environmental Monitoring and Assessment Program — QA Glossary [Last updated on 2/21/2016].
https://archive.epa.gov/emap/archive-emap/web/html/qa_terms.html

USEPA [U.S. Environmental Protection Agency]. 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4.

<https://www.epa.gov/sites/default/files/2015-06/documents/g4-final.pdf>.

USGS [U.S. Geological Survey]. 1998. Principles and Practices for Quality Assurance and Quality Control. Open-File Report 98-636.

<https://pubs.usgs.gov/of/1998/ofr98-636/pdf/ofr98636.pdf>.