GSI Water Solutions, Inc.

TECHNICAL MEMORANDUM

Emerging Pollutant Evaluation for Individual Underground Injection Control Permit Renewals

To: Participating UIC WPCF Permit Holders

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This Technical Memorandum (TM) was prepared by GSI Water Solutions, Inc. (GSI) to summarize an evaluation of emerging pollutants in stormwater that is required to be submitted with the renewal application for many individual Underground Injection Control (UIC) Water Pollution Control Facilities (WPCF) permits in Oregon.

1. Background

This section provides background information about the UIC permit requirement to prepare an emerging pollutant evaluation (Section 1.1), the permittees that contributed to this emerging pollutant evaluation both financially and technically (Section 1.2), a March 2022 meeting with the Oregon Department of Environmental Quality (DEQ) to discuss the scope of the emerging pollutant evaluation (Section 1.3), the purpose and objectives of the evaluation (Section 1.4), and the organization of the TM (Section 1.5).

1.1 Permit Requirement for an Emerging Pollutant Evaluation

In 2012, DEQ began issuing individual UIC WPCF permits to cities, service districts, counties, and businesses that use UICs to manage stormwater runoff from public rights of ways, building roofs, and/or parking lots. DEQ used a common template for the permits, and, from 2012 to 2017, issued approximately 40 permits. The permits are set to expire after 10 years, and permittees will be preparing permit renewal applications in the coming years.

The individual UIC WPCF permits require permittees to develop an emerging pollutant evaluation that assesses emerging pollutant types and concentrations, and address the implications of any significant findings for protection of beneficial uses and for the application of best management practices[1]. Emerging pollutant evaluations are required in the fifth[2] and final year of the permit. This TM is the emerging pollutant evaluation that is required in the final year of the permit, and is to be submitted with each permittee's permit renewal application.

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[1] In most permits, this requirement is found in Schedule D, condition 5

[2] The fifth-year emerging pollutant evaluation was collaboratively prepared by multiple ACWA jurisdictions and was submitted to DEQ on September 21, 2017 (GSI, 2017).

1.2 Participating Jurisdictions

Many cities, service districts, and counties that use UICs to manage stormwater runoff are members of the Oregon Association of Clean Water Agencies (ACWA), and meet approximately quarterly as the Groundwater Committee to discuss UIC regulatory issues and protection of groundwater quality. In the Fall of 2021, the Groundwater Committee formed the Emerging Pollutant Evaluation Work Group (the Work Group) to develop a scope of work for meeting the permit requirement to prepare an emerging pollutant evaluation. The Work Group met on October 11, 2021, and November 16, 2021, to: (1) identify emerging pollutants to include in the evaluation and (2) determine methods for evaluating the risk the pollutants posed to degrading the quality of groundwater that is used as drinking water. In this TM, we focus on "the quality of groundwater that is used as drinking water" because the exposure pathway of concern involves migration of pollutants to groundwater during stormwater infiltration, capture by a drinking water well, and ingestion by humans.

The scope of work for the emerging pollutant evaluation was presented to the Groundwater Committee during the January 13, 2022, meeting, and the jurisdictions in Table 1 contributed financially to hire a consultant (GSI Water Solutions, Inc.) to perform the evaluation.

Table 1. Participating Permittees.

Permitee	Permit No.	Permit Expiration Date
City of Gresham	103043	11/30/2022
City of Eugene	103047	12/31/2022
City of Redmond	103050	1/31/2023
City of Bend	103052	4/30/2023
Clackamas County WES	103059	6/30/2023
City of Keizer	103068	9/30/2023
Multnomah County	103076	3/31/2024
City of Canby	103077	3/31/2024
City of Milwaukie	103089	7/31/2024
City of La Grande	103093	9/30/2024
Lane County	103100	10/31/2024
City of Portland	102830	4/30/2025

It should be noted that in addition to financially contributing to the emerging pollutant evaluation, the participating permittees contributed technically to the evaluation during Work Group meetings, Groundwater Committee meetings, and a special meeting to discuss evaluation results on August 31, 2022.

1.3 March 2022 Meeting With DEQ

UIC permits and the accompanying permit evaluation reports do not define emerging pollutants and do not provide detail on the scope of an emerging pollutant evaluation. Therefore, development of a successful emerging pollutant evaluation requires that UIC permittees work closely with DEQ to agree on a scope that meets the permit requirement. On March 3, 2022, representatives from DEQ attended the ACWA Groundwater Committee meeting to discuss the emerging pollutant evaluation and other UIC-related issues. During the meeting, GSI presented a review of the previous (5th year) emerging pollutant evaluation, the emerging pollutants proposed for inclusion in the current emerging pollutant evaluation (including the methods that were used to select the pollutants), and the methods that would be used to evaluate the risk that the pollutants pose to degrading the quality of groundwater that is used as drinking water. DEQ concurred that the emerging pollutants selected for the evaluation appeared to be based on sound reasoning and were appropriate to include in the evaluation.

1.4 Purpose and Objectives

The primary purpose of this emerging pollutant evaluation is to identify emerging pollutants that pose the highest risk of degrading the quality of groundwater that is used as drinking water. A secondary purpose is to discuss implications on best management practices and protection of the beneficial uses of groundwater, with the understanding specific actions taken based on the results of the study will be jurisdiction-specific (reflecting the fact that stormwater quality, use of groundwater as a source of drinking water, UIC design characteristics, depth to groundwater, and long-term stormwater management strategies are jurisdiction-specific). The objectives of the emerging pollutant evaluation are:

- Identify emerging pollutants to include in the evaluation based on conversations with municipalities that use groundwater as a source of drinking water, a review of scientific literature, and pollutants that should be carried-over from the 5th year emerging pollutant evaluation (GSI, 2017).
- Evaluate whether any of the emerging pollutants are associated with pesticide degradates that should be included in the emerging pollutant evaluation.
- Conduct a desktop evaluation of the toxicity, mobility, and environmental persistence of the emerging pollutants to identify the pollutants that pose the highest risk of degrading the quality of groundwater that is used as drinking water.
- Summarize available stormwater quality data to further refine the list of pollutants that pose the highest risk of degrading the quality of groundwater that is used as drinking water.
- Develop a “watch list” of pollutants that should be considered for inclusion in a future emerging pollutant evaluation.

1.5 TM Organization

The remainder of this TM is organized as follows:

- **Section 2: Methods.** Presents the methods used to identify emerging pollutants; evaluate pollutant toxicity, mobility, and persistence; summarize stormwater quality data; identify pesticide degradates; and develop a “watch list” of pollutants for potential inclusion in a future emerging pollutant evaluation.
- **Section 3: Results.** Presents the emerging pollutants that were included in the emerging pollutant evaluation; identifies degradates of pesticides that were considered for inclusion in the emerging pollutant evaluation; summarizes the pollutants in stormwater that pose the highest risk of degrading the quality of groundwater used as drinking water based on toxicity, mobility, persistence, and concentrations in stormwater; and presents a “watch list” of pollutants.
- **Section 4: Conclusions.** Presents conclusions from the emerging pollutant evaluation.

2. Methods

This section documents the methods that were used to identify emerging pollutants (Section 2.1); degradates of the emerging pollutants (Section 2.2); emerging pollutants with the highest risk of degrading the quality of groundwater used as drinking water (Section 2.3); and emerging pollutants to add to a “watch list” to be considered for inclusion in a future emerging pollutant evaluation (Section 2.4).

2.1 Methods to Identify Emerging Pollutants

The Work Group identified emerging pollutants based on conversations with municipalities that use groundwater as a source of drinking water (Section 2.1.1), results of the 5th year emerging pollutant evaluation (Section 2.1.2), and a review of the scientific literature (Section 2.1.3).

2.1.1 Conversation with Municipalities that Use Groundwater as a Source of Drinking Water

The City of Gresham, City of Portland, City of Keizer and City of Bend, all of whom are members of the Work Group, use groundwater as a source of municipal drinking water. These Work Group members interviewed representatives from their respective water departments to identify emerging pollutants that are currently a concern for drinking water providers.

2.1.2 Results of the 5th Year Emerging Pollutant Evaluation

The 5th year emerging pollutant evaluation focused on the types and concentrations of pesticides in urban stormwater. Specifically, a stormwater quality dataset comprised of 248 unique pesticides was statistically summarized and compared to regulatory standards, and a subset of the pesticides was identified as more common in stormwater (if they were detected in more than 15 percent of samples) and detected at higher concentrations in stormwater (if they occurred at average concentrations of more than 10 percent of their regulatory standard). The Work Group reviewed these pesticides that are more common and occur at a higher concentration in stormwater (23 pesticides met at least one of these criteria in the 5th year emerging pollutant evaluation), and carried eight of the pesticides forward to this emerging pollutant evaluation. In addition, the Work Group carried forward other pesticides from the 5th year emerging pollutant evaluation if they were “pesticides of interest” (i.e., based on recent media reporting or common use in the urban environment).

2.1.3 Scientific Literature Review

The Work Group held discussions with the Groundwater Committee and Kevin Masterson (former DEQ Toxics Coordinator and currently at Stony Creek Consulting) to identify pollutants that have been the subject of recent scientific studies focusing on emerging pollutants in stormwater runoff.

2.2 Methods to Identify Degradates of the Emerging Pollutants

Degradates are the product of environmental transformation of a parent pesticide, and surface water sampling has demonstrated that degradates comprise a significant share of total pesticide load in streams (USGS, 1998). Based on a review of scientific literature, GSI compiled a list of pesticide degradates associated with the emerging pollutants that were identified using the methods summarized in Section 2.1. It is important to note that GSI did not consider which degradates were likely to be found in stormwater (i.e., GSI did not restrict the types of degradates to those that only form under aerobic conditions). Degradates were included in the emerging pollutant evaluation if: (1) a human-health-based regulatory standard for the degradate could be found, (2) the human-health-based regulatory standard indicated that the toxicity of the degradate to humans was “moderate” or “high,” and (3) information used to develop a mobility score and persistence score (K_{oc} and half-life, respectively) was readily available. It should be noted that human health toxicity information is much more commonly available for pesticides than for their degradates (Bexfield et al., 2021).

2.3 Methods to Identify Pollutants with the Highest Risk of Degrading the Quality of Groundwater Used as Drinking Water

This section summarizes the methods that were used to evaluate the toxicity, mobility, and persistence of the emerging pollutants (Section 2.2.1) and to develop a classification system that was used to identify the pollutants that pose the highest risk of degrading the quality of groundwater used as drinking water (Section 2.2.2).

2.3.1 Evaluation of Pollutant Toxicity, Mobility and Persistence

GSI conducted a review of the scientific literature to summarize data on the toxicity, mobility, and persistence of the emerging pollutants, and assign them a score based on the criteria in Table 2. A "high" score indicates that a pollutant is relatively more toxic (i.e., a lower regulatory standard), more mobile (i.e., does not sorb to soil), and more persistent (i.e., a longer half-life). Conversely, a "low" score indicates that a pollutant is relatively less toxic (i.e., a higher regulatory standard), less mobile (i.e., sorbs to soil), and less persistent (i.e., a shorter half-life).

Table 2. Criteria for Evaluating Pollutant Toxicity, Mobility, and Persistence.

Score	Toxicity (Regulatory Standard)	Mobility (Median K_{oc})	Persistence (half-life)
High	< 10 ug/L	< 1,000 L/Kg	> 500 days
Medium	10 ug/L – 100 ug/L	1,000 L/Kg – 50,000 L/Kg	50 – 500 days
Low	> 100 ug/L	> 50,000 L/Kg	< 50 days

Notes

ug/L = micrograms per liter

L/Kg = liters per kilogram

The following bullets describe the methods that were used to assign toxicity, mobility, and persistence scores to the emerging pollutants.

- **Toxicity.** Emerging pollutants were assigned a toxicity score based on the lowest human health-based regulatory screening level value for ingestion of the pollutant from tap water. Specifically, GSI compiled:
    - DEQ Risk-Based Concentrations (RBCs) for the urban residential exposure scenario (DEQ, 2018),
    - Environmental Protection Agency (EPA) Regional Screening Levels (RSLs), Ingestion Screening Level for a Child, Residential Tap Water, THQ = 1, TR=1E-06 (EPA, 2022),
    - EPA Human Health Benchmarks for Pesticides (HHBPs), acute or chronic (whichever is lower) (EPA, 2021),
    - EPA Maximum Contaminant Levels (MCLs), and
    - United States Geological Survey (USGS) Health-Based Screening Levels (HBSLs) (USGS, 2018).

  If a DEQ RBC, EPA RSL, EPA HHBP, EPA MCL, or USGS HBSL had not been developed for an emerging pollutant, then GSI identified a regulatory standard from another source [specifically, Minnesota Department of Health Guidance Value for ingestion by humans through the drinking water pathway (Minnesota DOH, 2022a; Minnesota DOH, 2022b) and Montana Department of Environmental Quality Human Health Standards for Groundwater (Montana DEQ, 2019)].

- **Mobility.** Pollutants were assigned a mobility score based on the pollutant-specific organic carbon partitioning coefficient, K_{oc}. The K_{oc} (which has units of liters per kilogram, or L/kg) describes the tendency of an organic pollutant to partition between the aqueous and solid phases. Higher K_{oc} values indicate that a pollutant binds strongly to soils (i.e., a less mobile pollutant) and lower K_{oc} values indicate that a pollutant has a tendency to remain in the aqueous phase (i.e., a highly mobile pollutant). GSI compiled K_{oc} values for the emerging pollutants measured from laboratory studies and calculated K_{oc} statistics (number of values, minimum, median, and maximum). The median K_{oc} was used to assign a mobility score according to the criteria in Table 2.

- **Persistence.** Pollutants were assigned a persistence score based on the pollutant half-life, which is the time required for pollutant concentrations to decline by one half. GSI compiled half-lives for the emerging pollutants from field and laboratory studies. To develop persistence scores that are representative of the conditions that pollutants experience during infiltration with stormwater, only half-lives for attenuation by biodegradation in soil and groundwater under aerobic conditions were used. Half-lives measured under anaerobic conditions, half-lives measured in surface water, and half-lives measured for a photolysis pathway (i.e., exposure to sunlight) were not used. GSI calculated statistics for pollutant half-lives (number of values, minimum, median, and maximum), and assigned a persistence score according to the criteria in Table 2.

2.3.2 Classification of Risk Posed to Groundwater Quality

GSI tabulated the toxicity, mobility, and persistence scores, and assigned emerging pollutants to one of three tiers with the objective of classifying risk posed to the quality of groundwater used as drinking water:

- **Tier 1 Pollutants (Highest Risk).** Toxicity, mobility, and persistence scores were all "medium" or "high."
- **Tier 2 Pollutants (Moderate Risk).** At least one score (toxicity, mobility, or persistence) was "low" (i.e., the toxicity, mobility, and persistence scores were "high," "medium," and/or "low").
- **Tier 3 Pollutants (Lowest Risk).** No scores (toxicity, mobility, or persistence) were "high" (i.e., the toxicity, mobility, and persistence scores were all "low" or "medium").

Tier 1 pollutants are considered to pose the highest potential of degrading the quality of groundwater used as drinking water because their mobility and persistence are medium or high, and they are highly toxic to humans.

GSI further refined the list of Tier 1 pollutants by compiling stormwater quality data from the 5th year emerging pollutant evaluation (because in order to pose a risk of degrading groundwater quality due to stormwater infiltration, the pollutant must be present in stormwater). The stormwater quality data were statistically analyzed (number of samples, minimum concentration, median concentration, average concentration, maximum concentration, frequency of detection, and frequency of exceeding the lowest regulatory standard) to assess the presence of the pollutant in stormwater.

2.4 Methods to Develop a Watch List of Pollutants for Potential Inclusion in a Future Emerging Pollutant Evaluation

GSI's April 18, 2022, scope of work for the emerging pollutant evaluation assumed that 16 pollutants would be evaluated. Over the course of reviewing scientific literature for emerging pollutants, it was expected that GSI would encounter other emerging pollutants that would be good candidates for evaluation that, due to budget constraints, could not be included in the current evaluation. GSI included these pollutants on a "watch list" for potential inclusion in a future emerging pollutant evaluation.

3. Results

This section lists the emerging pollutants identified by the Work Group (Section 3.1), identifies pesticide degradates (Section 3.2), identifies the emerging pollutants that pose the highest risk of degrading the quality of groundwater used as drinking water (Section 3.3), and presents a "watch list" of pollutants for potential inclusion in a future emerging pollutant evaluation (Section 3.4).

3.1 Emerging Pollutants

The 17 emerging pollutants that were included in the evaluation, and the reason for their inclusion in the evaluation, are shown in Table 3. Note that one pollutant (glyphosate isopropylamine) was added by GSI to the initial list of 16 pollutants identified by the Work Group because it is closely related to glyphosate.

Table 3. Emerging Pollutants.

Emerging Pollutant	Reason for Including	Common Uses
2, 4-D	Carry-forward from 5th Year evaluation, detected in >15% of samples	Herbicide applied in agriculture, forestry, and the urban environment
2,6-dichlorobenzamide	Carry-forward from 5th Year evaluation, detected in >15% of samples	Metabolite of dichlobenil, which is an herbicide used to control weeds and grasses in agricultural and urban environments
6PPD Quinone	Emerging pollutant based on literature review	Degradate of 6PPD, which is an antiozonant and antioxidant in rubber tires
AMPA	Carry-forward from 5th Year evaluation, "pollutant of interest" because a degradate of glyphosate (herbicide currently in the news). Note that glyphosate and glyphosate isopropylamine are also included in this emerging pollutant evaluation (see below).	Degradate of glyphosate
Atrazine	Carry-forward from 5th Year evaluation, detected in >15% of samples	Herbicide applied in agriculture, golf courses, and residential lawns
Bifenthrin	Carry-forward from 5th Year evaluation, included because of common current use in the urban environment	Insecticide used in the urban environment
Diuron	Carry-forward from 5th Year evaluation, detected in >15% of samples and averages >20% of regulatory standard	Herbicide used in agriculture and the urban environment (along streets, residential aquariums and ponds, paints, coatings, and adhesives)
DCOI	Emerging pollutant based on literature review	Wood preservative that is a candidate to replace pentachlorophenol on utility poles
Fipronil	Carry-forward from 5th Year evaluation, detected in >15% of samples	Insecticide used to control pests on lawns, pet-care products, and agricultural applications
Glyphosate	Carry-forward from 5th Year evaluation, "pollutant of interest" (herbicide currently in the news)	Herbicide used in agriculture, forestry, and the urban environment
Imidacloprid	Carry-forward from 5th Year evaluation, "pollutant of interest" because of association with DCOI (wood preservative replacement for pentachlorophenol)	Insecticide used in agriculture and the urban environment
MCPA	Carry-forward from 5th Year evaluation, detected average >20% of regulatory standard	Herbicide used in agriculture, forestry, and rights-of-way
Nonylphenols	Identified as a pollutant of concern by Kevin Masterson (Stony Creek Consulting)	Surfactant used in industrial processes, laundry detergents, personal hygiene, automotive applications, latex paints, and lawn care products
PFAS	Identified as a pollutant of concern by drinking water providers	A class of thousands of chemicals used in consumer, commercial, and industrial products
Simazine	Carry-forward from 5th Year evaluation, detected average >20% of regulatory standard	Herbicide used in the urban environment
Sulfometuron Methyl	Carry-forward from 5th Year evaluation, detected in >15% of samples	Herbicide used mostly in nonagricultural situations (roadsides, industrial facilities, and public lands)
Glyphosate Isopropylamine	Closely related to glyphosate	Herbicide used in the urban environment

3.2 Pesticide Degradates

Table 4 summarizes pesticide degradates that GSI compiled based on a review of the scientific literature. The degradates were not included in the emerging pollutant evaluation because: (1) a human-health-based regulatory standard could not be found, or (2) a human-health-based regulatory standard was found but the degradate was considered to have a "low" toxicity to humans (using the criteria in Table 2). Specifically, EPA RSLs were found for benzoic acid (80,000 ug/L), formaldehyde (4,000 ug/L), and ortho-chlorobenzoic acid (600 ug/L), which are greater than the 100 ug/L criteria used to identify emerging pollutants with a "low" toxicity to humans.

Table 4. Pesticide Degradates.

Pesticide	Degradates
2,4-D	2,4-DCP; 3,5-dichlorocatechol; 2,4-dichloro-cis-cis-muconate; 2-chlorodienelactone; 2-chloromaleylacetate; maleylacetate; B-ketoadipate
2,6-dichlorobenzamide	2,6-DCBA; **ortho-chlorobenzoic acid**; 2,6-dichlorobenzene; **benzoic acid**; 2,6-dichloro-3,4-dihydroxybenzene; 2,6-dichloro-3,4-dihydroxybenzoic acid
AMPA	Methylamine; phosphonoformaldehyde; phosphate; **formaldehyde**
Atrazine	Hydroxyatrazine; N-isopropilamelide; Cyanurate; deisopropylatrazine (DIA); deethylatrazine (DEA)
Bifenthrin	TFP acid; BP acid; BP alcohol; Hydroxymethyl-bifenthrin; 2'- or 4'-OH-hydroxymethyl-bifenthrin; 4sy'-OH-bifenthrin; 4'-OH-BP alcohol; Dimethoxy BP alcohol; cis-hydroxymethyl TFP acid; trans-hydroxymethyl TFP acid; Dimethoxy-BP acid; 4'-OH-BP acid; 4'-methoxy BP acid
Diuron	DCPMU; DCPU; DCA
Fipronil	Sulfone; desulfinyl; amide; sulfide
Glyphosate	AMPA, glyoxylate, phosphate, methylamine, phosphonoformaldehyde, acetylglyphosate, phosphate, arcosine, glycine, **formaldehyde**
Imidacloprid	6-chloro-nicotinaldehyde; 6-chloro-N-methylnicotinacidamide; 6-chloro-3-pyridyl-methylethylendiamine; 6-hydroxynicotinic acid; imidacloprid guanidine; imidacloprid urea
MCPA	MCP
Simazine	Deisopropylatrazine (DIA)
Sulfometuron Methyl	Methyl 2-(aminosulfonyl)benzoate, 2-amino-4,6-dimethylpyrimidine, 2-(aminosulfonyl)benzoic acid, 2-amino-4,6-dimethylpyrimidine
Glyphosate Isopropylamine	None identified

Notes
Bold text indicates a degradate with a human-health-based regulatory standard (i.e., EPA RSL)

3.3 Identification of Emerging Pollutants that Pose the Highest Risk of Degrading Groundwater Used as Drinking Water

The risk scores for the toxicity, mobility, and persistence of each emerging pollutant are summarized in Table 5. Seven of the emerging pollutants fall into the highest risk category (i.e., Tier 1) because the risk scores are all medium or high. These pollutants pose the highest risk of migrating to groundwater and degrading groundwater quality because they are moderately to highly toxic, mobile, and persistent.

- The regulatory standards that were used to assign a toxicity score, and the resulting toxicity score, are presented in Table A.1 of Attachment A.
- The K_{oc} statistics that were used to assign a mobility score, and the resulting mobility score, are presented in Table A.2 of Attachment A. Individual K_{oc} values are presented in Table B.1 of Attachment B.

- Half-life statistics that were used to assign a persistence score, and the resulting persistence score, are presented in Table A.3 of Attachment A. Individual half-life values are presented in Table B.2 of Attachment B.

Table 5. Summary of Pollutant Risk Scoring.

Tier	Emerging Pollutant	Toxicity Score	Mobility Score	Persistence Score
1 *High & Medium*	PFAS	High	High	High
	Diuron	High	High	Medium
	Fipronil	High	High	Medium
	Atrazine	High	High	Medium
	Simazine	High	High	Medium
	2,4-D	Medium	High	Medium
	4-nonylphenol	Medium	Medium	Medium
2 *High, Medium, & Low*	Imidacloprid	Low	High	High
	MCPA	High	High	Low
	2,6-dichlobenzamide (BAM)	Low	High	Medium
	Sulfometuron methyl	Low	High	Low
3 *Medium & Low*	6PPD Quinone	--	Medium	Medium
	Aminomethylphosphonic acid (AMPA)	Low	Medium	Medium
	Bifenthrin	Low	Low	Medium
	Glyphosate	Low	Medium	Low
	Glyphosate Isopropylamine	--	Medium	Low
	DCOI	--	Low	Low

Table 6 shows the frequency that the Tier 1 pollutants that were detected in urban stream and stormwater samples based on stormwater quality data analyzed during the 5th year emerging pollutant evaluation (collected from 2005 to 2017)[3] and sampling for PFAS (conducted by the City of Portland in 2020 and 2021), and the frequency that they exceed the lowest human health based regulatory standard. Note that there are many other data sources that have shown the presence of these compounds, but this data is provided as a snapshot of existing data collected by ACWA UIC and MS4 communities.

Pollutant concentrations are presented based on the stormwater sampling location—UICs, urban streams, or stormwater outfalls. Note that frequency of detection in urban streams is not necessarily the same as the frequency of detection at UICs. While this difference is sometimes due to sample size (e.g., see Fipronil, Atrazine, and Simazine), it also may be due to the fact that urban streams receive agricultural runoff (either historically or currently) from further upstream in the watershed. Additional sampling at UICs would provide more information about concentrations of emerging pollutants at UICs. Pollutant concentrations are presented in Table A.4 of Attachment A.

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[3] Note that the statistics presented in Table 6 may be different than the statistics presented in the 5th year emerging pollutant evaluation (GSI, 2017), even though both Table 6 and the 5th year emerging pollutant evaluations are based on the same data sets. The difference occurs because the 5th year evaluation excluded samples from statistical analysis if the method reporting limit exceeded a regulatory standard. Table 6 includes all stormwater quality samples.

Table 6. Tier 1 Pollutants: Frequency of Detection and Frequency of Regulatory Standard Exceedance.

Emerging Pollutant	Number of Samples	Detection at UICs [1]	Detection in Urban Streams	Detection at Stormwater Outfalls	Frequency of Lowest Regulatory Standard Exceedance
PFAS	10	No Data	No Data	40% to 100% [2]	0.0%
Diuron	581	13/50 (26%) [3]	367/531 (69.1%) [3]	No Data	1.4%
Fipronil	43	0/4 (0.0%) [4]	8/39 (20.5%) [4]	No Data	0.0%
Atrazine	917	0/4 (0.0%) [5]	59/913 (6.5%) [5]	No Data	0.0%
Simazine	922	0/4 (0.0%) [6]	341/918 (37.1%) [6]	No Data	0.2%
2,4-D	2,051	327/1,859 (17.6%) [7]	20/192 (10.4%) [7]	No Data	0.0%
4-nonylphenol	No Data	No Data	No Data	No Data	No Data

Notes

(1) Stormwater samples collected at or up-pipe from the end-of-pipe where stormwater discharges into the UIC

(2) Frequency depends on the specific compound

(3) UIC samples from Portland and Multnomah County datasets; urban stream samples from Eugene, Salem, USGS (2008), and PSP datasets. See GSI (2017) for details.

(4) UIC samples from Multnomah County dataset; urban stream samples from Clackamas, Eugene, and Salem datasets. See GSI (2017) for details.

(5) UIC samples from Multnomah County dataset; urban stream samples from Salem, Eugene, USGS (2008), and PSP datasets. See GSI (2017) for details.

(6) UIC samples from Multnomah County dataset; urban stream samples from Salem, Eugene, USGS (2008), and PSP datasets. See GSI (2017) for details.

(7) UIC samples from Gresham, Multnomah County, and Portland datasets; urban stream samples from Salem, USGS (2008), and PSP datasets. See GSI (2017) for details.

It is important to note that the PFAS results are stormwater samples collected in north and northeast industrial Portland, and may not be representative of residential and commercial stormwater. The other pollutants in Table 6 are from the 5th year emerging pollutant evaluation (stormwater samples are primarily from residential and commercial areas of town).

3.4 Watch List of Pollutants for Potential Inclusion in a Future Emerging Pollutant Evaluation

The following bullets present a list of emerging pollutants in stormwater that GSI identified while conducting this emerging pollutant evaluation.

- Pesticides found regularly in surface water that weren't assessed in early studies of pesticide occurrence in Oregon (i.e., prior to 2012) (pers. comm., K. Masterson, 2022):
    - Dimenthamid-p, a herbicide used primarily in agricultural applications but also for non-agricultural weed control (Minnesota DOH, 2013).
    - Azoxystrobin, a fungicide
    - Chlorothalonil, fungicide and wood protectant with significant nonagricultural use (15 million pounds used from 1990 to 1996) (EPA, 1999).
    - Aminocyclopyrachlor, a weed killer used by the Oregon Department of Transportation (ODOT) and other public entities along rights of way. The substance was responsible for

the death of nearly 1,500 Ponderosa Pines near Sisters, and was recently banned in Oregon (OPB, 2018).

4. Conclusions

The primary conclusions of this emerging pollutant evaluation are:

- Seven emerging pollutants have the highest potential to pose a risk to degrade the quality of groundwater used as drinking water because they are moderately to highly mobile, highly persistent, and highly toxic to humans: PFAS, diuron, fipronil, atrazine, simazine, 2,4-D, and 4-nonylphenol.
- Three of these pollutants—fipronil, diuron, and 2,4-D—have been evaluated using pollutant fate and transport modelling (GSI, 2017; GSI, 2011). The conclusion from the fate and transport modeling is that these pollutants generally do not pose a risk of degradation of the quality of groundwater used for drinking water as long as a five foot vertical separation distance is present between the bottom of the UIC and seasonal high groundwater. The four remaining emerging pollutants—PFAS, atrazine, simazine, and 4-nonylphenol—are characterized by uncertainty regarding fate and transport because no fate and transport modeling has been performed.
- The emerging pollutant that potentially poses the highest risk of degrading groundwater quality is PFAS because it is highly mobile, highly persistent, and highly toxic to humans. PFAS have been used since the 1940s in a wide variety of consumer products (ITRC, 2020). PFAS can be transported in the atmosphere in the gas phase and as particulates, and have been found surface snow of the artic peninsula (Mahmoudnia et al., 2022) and rainwater (Cousins et al., 2022). Additional stormwater quality data is needed to better-characterize the concentration of PFAS in municipal stormwater because: (1) only 10 stormwater analyses for PFAS were included in this emerging pollutant evaluation, and (2) the PFAS stormwater quality data is from an industrial area of north and northeast Portland and may not be representative of the stormwater that typically drains to public UICs (City of Portland BES, 2021).
- We were unable to find stormwater quality data for nonylphenols. Therefore, concentrations of nonylphenols in municipal stormwater runoff is not currently well-understood.

We recommend that jurisdictions consider these conclusions when evaluating implications of this emerging pollutant evaluation on best management practices and protection of the beneficial uses of groundwater. One consideration is that many of the emerging pollutants have not been sampled in stormwater (e.g., nonylphenols), have only been sampled in Oregon in industrial stormwater (PFAS), or have not been sampled frequently at UICs (Fipronil, Atrazine, Simazine). Another consideration is the fact that these pesticides are present in stormwater and urban streams suggests they are not being used properly (according to manufacturer's directions) and that public education and regulation (i.e., from the Oregon Department of Agriculture or Department of Environmental Quality) is warranted.

Specific actions taken based on the results of the study will be jurisdiction-specific (reflecting the fact that stormwater quality, use of groundwater as a source of drinking water, UIC design characteristics, depth to groundwater, and long-term stormwater management strategies are jurisdiction-specific).

5. References

AG, 2011. Diuron Environment Assessment. Australian Government Australian Pesticides and Veterinary Medicines Authority, 247 pp., July.

Ahangar, A. G., Smernik, R. J., and R. S. Kookana, 2008. Role of the chemistry of soil organic matter on the sorption of diuron. In: Environmental Toxicology II, Kungolos, A. G., Brebbia, C. A., and Zamorano, M., Eds. WIT Press, Southampton, Boston, 327 – 336.

Ahrens, W. H. 1994. Herbicide Handbook. W. H. Ahrens (eds.). 7th ed. Weed Science Society of America. Champaign, IL.

Ahrens, L., Yeung, Yeung, L.W.Y., Taniyasu, S., Lam, P.K.S., and N. Yamashita. 2011. Partitioning of perfluorooctanoate (PFOA), perfluorooctane sulfonate (PFOS), and perfluorooctane sulfonamide (PFOSA) between water and sediment. Chemosphere, Volume 85: 731-737.

ATSDR. 2003. Toxicological Profile for Atrazine. September.

ATSDR. 2020. Toxicological Profile for Glyphosate. August.

ATSDR. 2021. Toxicological Profile for Perfluoroalkyls. May.

ATSDR. 2020. Toxicological Profile for 2,4-Dichlorophenoxyacetic Acid (2,4-D). July.

Barriuso, E., S. Houto, S., and C. Serra-Wittling. 1997. Influence of compost addition to soil on the behavior of herbicides. Pesticide Science, Volume 49: 65-75.

Beltran, J., Gerritse, R. G., and F. Hernandez. 1998. Effect of flow rate on the adsorption and desorption of glyphosate, simazine, and atrazine in columns of sandy soils. European Journal of Soil Science, Volume 49: 149-156.

Bento, C. P. M. 2018. Glyphosate and Aminomethylphosphonic Acid (AMPA) Behavior in Loess Soils and Off-site Transport Risk Assessment. October. Available online at: https://edepot.wur.nl/458142.

Bergstrom, L., Borjesson, E., and J. Stenstrom. 2011. Laboratory and Lysimeter Studies of Glyphosate and Aminomethylphosphonic Acid in a Sand and a Clay Soil.

Bexfield, L. M., Belitz, K., Lindsey, B. D., Toccalino, P. L., and L. H. Nowell. 2021. Pesticides and pesticide degradates in groundwater used for public supply across the United States: Occurrence and Human-Health Context. Journal of Environmental Science and Technology, Vol. 55, No. 1, pp. 362 – 372.

Bramble, F. Q., Behmke F. D., and G. I. Norwood, 1998. Batch equilibrium (adsorption/desorption) of 14C-Diuron, fenuron, and N'-(3-chlorophenyl)-N,N-Dimethylurea on Soil.

CalEPA. 2022. Product-Chemical Profile for Motor Vehicle Tires Containing N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD). March 2022 Final Version. 102 pg. Available online at: https://dtsc.ca.gov/wp-content/uploads/sites/31/2022/05/6PPD-in-Tires-Priority-Product-Profile_FINAL-VERSION_accessible.pdf

Chen, Y. C., Lo, S. L., Li, N. H., Lee, Y. C., and J. Kuo. 2013. Sorption of perfluoroalkyl substances (PFASs) onto wetland soils. Desalin. Water Treat., Volume 51: 7469-7475.

Cousins, I. T., Johansson, J. H., Salter, M. E., Sha, B., and M. Scheringer. 2022. Outside the Safe Operating Space of a New Planetary Boundary for Per- and Polyfluoroalkyl Substances (PFAS). Environmental Science and Technology, Vol. 56, No. 16, 11172 – 11179.

Cox, L., Koskinen, W. C., and P. Y. Yen. 1997. Sorption-desorption of imidacloprid and its metabolites in soils. Journal of Agricultural and Food Chemistry. Volume 45: 1468-1472.

Cox, L., Hermosin, M. C., and J. Cornejo. 1999. Leaching of simazine in organic-amended soils. Communications of Soil Science Plant Anal. Volume 30: 1607-1706.

Cox, L., Celis, R., Hermosin, M. C., and J. Cornejo. 2000. Natural soil colloids to retard simazine and 2,4-D leaching in soil. Journal of Agricultural Food Chemistry. Volume 48: 93-99.

City of Portland BES. 2021. 2020-2021 PFAS Stormwater Sampling Results, Columbia Slough ECSI No. 1283. Prepared by: City of Portland Bureau of Environmental Services. Prepared for: Oregon Department of Environmental Quality.

DEQ. 2018. Risk-Based Concentrations for Individual Chemicals. State of Oregon Department of Environmental Quality Environmental Cleanup Program. May.

Doran, G., Eberbach, P., and S. Helliwell, 2006. The sorption and Degradation of the rice pesticides fipronil and thiobencarb on two Australian rice soils, Australian journal of soil research, vol. 44, pp. 599-610.

Dores, E. F. G. C., Spadotto, C. A., Weber, O. L. S., Carbo, L., Vecchiato, A. B., and A. A. Pinto, 2007. Environmental Behavior of Metolachlor and Diuron in a Tropical Soil in the Central Region of Brazil. Water Air Soil Pollution, Vol 197, pp. 175—183.

Dousset, S., Mouvet, C., and M. Schiavon. 1994. Sorption of terbuthylazine and atrazine in relation to the physico-chemico properties of three soils. Chemosphere, Volume 28, No. 3: 467-476.

Doyle, R., Oliver, G., Brown, P., Ratkowsky, D., Cumming, J. P. and J. Hingston. 2008. The Tasmanian River Catchment Water Quality Initiative. Report on Pesticide Fate and Behaviour in Tasmanian Environments. July. Available online at: https://eprints.utas.edu.au/7577/1/TIAR_Pesticide_Report.pdf.

Ecology. 2022. Stormwater Treatment of Tire Contaminants Best Management Practices Effectiveness. Final Report. June. Available online at: https://fortress.wa.gov/ecy/ezshare/wq/Permits/Flare/2019SWMMWW/Content/Resources/DocsForDownload/2022_SWTreatmentOfTireContaminants-BMPEffectiveness.pdf?utm_medium=email&utm_source=govdelivery.

EFSA. 2008. Conclusion regarding the peer review of the pesticide risk assessment of the active substance imidacloprid. EFSA Scientific Report 148, 120 p. Available online at: https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/j.efsa.2008.148r.

Enevoldsen, R. and R. K. Juhler. 2010. Perfluorinated compounds (PFCs) in groundwater and aqueous soil extracts: using inline SPE-LC-MS/MS for screening and sorption characterization of perfluorooctane suphonate and related compounds. Anal. Bioanal. Chem., Volume 398: 1161-1172.

EPA. 1995. National Primary Drinking Water Regulations—2,4-D. United States Environmental Protection Agency, Office of Water 4601. EPA 811-F-95-003h-T. October.

EPA. 1998. R.E.D. FACTS – Dichlobenil. Prevention, Pesticides and Toxic Substances. EPA-738-F-98-005. October. Available online at:

https://www3.epa.gov/pesticides/chem_search/reg_actions/reregistration/fs_PC-027401_1-Oct-98.pdf

EPA. 1999. Reregistration Eligibility Decision for Chlorothalonil. Prepared by: U. S. Environmental Protection Agency.

EPA. 2009. National Primary Drinking Water Regulations. May. Available online at: https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulation-table

EPA. 2012. Revised EFED Registration Review Problem Formulation for Dichlobenil. United States Environmental Protection Agency Office of Chemical Safety and Pollution Prevention. December 11. Available online at: EPA-HQ-OPP-2012-0395-0019_content.pdf.

EPA. 2015. DCOIT Final Work Plan. Registration Review: Initial Docket, Case Number 5023. March.

EPA. 2016. Estimation Programs Interface Suite ™ for Microsoft ® Windows, v. 4.11. United States Environmental Protection Agency, Washington, DC, USA.

EPA. 2021. 2021 EPA Human Health Benchmarks for Pesticides. Available online at: https://www.epa.gov/sdwa/human-health-benchmarks

EPA. 2022. Glyphosate Exposure Characterization. U.S. Environmental Protection Agency.

EPA. 2022. Regional Screening Levels (RSLs) Resident Tapwater Table. May. Available online at: https://semspub.epa.gov/work/HQ/402389.pdf

Fecko, A. 1999. Environmental Fate of Bifenthrin. Department of Pesticide Regulation: Environmental Monitoring and Pest Management Branch, pp. 1-8.

Fitzmaurice, M. and E. MacKenzie, 2002. 14C Fipronil: Degradation in Four soils at 20 C and two soils at 10 C (AE F124964), Document No. C018800, Aventis CropScience UK Limited, 17 January 2002.

Fossen, M. 2006. Environmental Fate of Imidacloprid. Environmental Monitoring, Department of Pesticide Regulation. 1001 I Street, Sacramento, CA. April.

Geosyntec. 2019. Appendix C: Kow, Koc and Mass Distribution Calculations. December. Available online at: https://files.nc.gov/ncdeq/GenX/consentorder/paragraph-16/FW-CAP-FINAL-12-31-2019-Appendix-C.pdf.

Godward, P. J., D. L. Quarmby, and D. J. Austin, 1992. M&B 46030-14C: Adsorption/Desorption on five soils: amendment to final report. Report No. 548, Rhone-Poulenc Agricultural Ltd., Essex, unpublished.

GSI. 2011. Pollutant Fate and Transport Model Results in Support of the City of Gresham UIC WPCF Permit – Proposed EDLs. Prepared by: GSI Water Solutions. Prepared for: City of Gresham.

GSI. 2017. Analysis of Urban Stormwater Quality Data and Pollutant Fate and Transport Simulations in Support of Emerging Pollutant Evaluations. Prepared by: GSI Water Solutions. Prepared for: City of Portland, City of Gresham, City of Eugene, City of Redmond, City of Bend, City of Canby, City of La Grande, Clackamas County WES, City of Keizer, Multnomah County, City of Milwaukie, and Lane County. September 21.

Guelfo, J. L. and C.P. Higgins. 2013. Subsurface transport potential of perfluoroalkyl acids at aqueous film-forming foam (AFFF)-impacted sites. Environmental Science and Technology, Volume 47, No. 9: 4164-4171.

Hassink, J., Klein, A., Kordel, W., and W. Klein. 1994. Behavior of herbicides in non-cultivated soils. Chemosphere. Volume 28: 285 – 295.

Higgins, C. and R. G. Luthy. 2006. Sorption of perfluorinated surfactants on sediments. Environmental Science and Technology. Volume 40, 7251-7256.

Hiki, K. and H. Yamamoto. 2022. Concentration and leachability of N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD) and its quinone transformation product (6PPD-Q) in road dust collected in Tokyo, Japan. Environmental Pollution, Volume 302.

Hiller, E., Khun, M., Zemanova, L., Jurkovic, L, and M. Bartal. 2006. Laboratory study of retention and release of weak acid herbicide MCPA by soils and sediments and leaching potential of MCPA. Plant Soil Environment, Volume 52, No. 12: 550-558.

Holtze, M. S., Sorensen, S. R., Sorensen, J., and J. Aamand. 2008. Microbial degradation of the benzonitrile herbicides dichlobenil, bromoxynil, and ioxynil in soil and subsurface environmentas – Insights into degradation pathways, persistent metabolites, and involved degrader organisms. Environmental Pollution, Volume 154, pp. 155-168.

HSDB (Hazardous Substances Data Bank). 2002. National Library of Medicine. http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB.

ITRC. 2020. History and Use of Per- and Polyfluoroalkyl Substances (PFAS). Available online at: https://pfas-1.itrcweb.org/fact_sheets_page/PFAS_Fact_Sheet_History_and_Use_April2020.pdf. April.

ITRC. 2022. PFAS Technical and Regulatory Guidance Document and Fact Sheets PFAS-1, Washington, DC: Interstate Technology & Regulatory Council, PFAS Team. Available online at: https://pfas-1.itrcweb.org/4-physical-and-chemical-properties/?print=pdf

Kasozi, G. N., Nkedi-Kizza, P., Agyin-Birikorang, S., and A. R. Zimmerman, 2010. Characterization of adsorption and degradation of diuron in carbonatic and noncarbonatic soils. Journal of Agricultural and Food Chemistry, Volume 58 (2), pp. 1055-1061.

Labadie, P. and M. Chevreuil. 2011. Partitioning behaviour of perfluorinated alkyl contaminants between water, sediment, and fish in the Orge River (nearby Paris, France). Environmental Pollution, Volume 159, No. 2: 391-397.

Madhun, Y. A. W., 1984. Interaction of Selected Herbicides with Soil Constituents. MS Thesis, Oregon State University, 171 pp.

Madhun, Y. A. and V. H. Freed, 1987. Degradation of the herbicides bromacil, diuron, and chlortoluron in soil. Chemosphere, Volume 16 (5): 1003—1011.

Meftaul, I. M., Venkateswarlu, K., Dharmarajan, R., Annamalai, P., and M. Megharaj. 2020. Movement and Fate of 2,4-D in Urban Soils: A Potential Environmental Health Concern. ACS Omega, 13287 – 13295.

Mahmoudnia, A., Mehrdadi, N., Baghdadi, M., and G. Moussavi. 2022. Change in Global PFAS Cycling as a Response of Permafrost Degradation to Climate Change. Journal of Hazardous Materials Advances, Vol. 5. February.

Mersie, W. and C. Seybold. 1996. Adsorption and desorption of atrazine, deethylatrazine, deisopropylatrazine, and hydroxyatrazine on Levy Wetland Soil Journal of Agricultural and Food Chemistry, Volume 44, No. 7: 1925-1929.

Milinovic, J., Lacorte, S., Vidal, M., and A. Rigol. 2015. Sorption behaviour of perfluoroalkyl substances in soils. Science of the Total Environment, Volume 511: 63-71.

Minnesota DOH. 2013. Dimethenamid and Drinking Water. June.

Minnesota DOH. 2022a. Aminomethylphosphonic Acid (AMPA) and Drinking Water. March.

Minnesota DOH. 2022b. Nonylphenols and Water. June.

Mohapatra, S., Ajuja, AK, and M. Deepa, 2010. Effect of Temperature on the Degradation of Fipronil in Soil. Pesticide Research Journal. Vol. 22 (2): 120-124.

Monsanto. 2005. Backgrounder: Glyphosate and Environmental Fate Studies. Updated: April 2005. Available online at: https://www.smcgov.org/media/40081/download?inline=.

Montana DEQ. 2019. Circular DEQ-7. Montana Numeric Water Quality Standards. Prepared by: Montana Department of Environmental Quality. June.

Montgomery, J. H. 1997. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. Volume V. Pesticide Chemicals. Lewis Publishers. Boca Raton, Florida.

Montgomery, J. H. and T. R. Crompton. 2018. Environmental Chemicals Desk Reference. CRC Press, Boca Raton, Florida.

Moorman, T. B., Jayachandran, K., and A. Reungsang. 2001. Adsorption and desorption of atrazine in soils and subsurface sediments. Soil Science, Volume 166, No. 12: 921 – 929.

Morton, P.A., Fennell, C., Cassidy, R., Doody, D., Fenton, O., Mellander, P.-E., and Jordan, P. 2019. A review of the pesticide MCPA in the land-water environment and emerging research needs. WIREs Water, Volume 7, Issue 1: 1-16.

Mukherjee, I. and Kalpana, 2006. Sorption of Fipronil in tropical soils. Bulletin of Environmental Contaminant Toxicology. Volume 76(2): 334-40.

NGWA Press. 2017. Groundwater and PFAS: State of Knowledge and Practice. 124 p.

NICNAS. 2016. Nonylphenols: Environment tier II assessment. February.

Nkedi-Kizza, P., Rao, P.S.C., and J. W. Johnson, 1983. Adsorption of diuron and 2,4,5-T on soil particle size separates. Journal of Environmental Quality, Volume 12, pp. 195-197.

NPIC. 2011. National Pesticide Information Center. Accessed by GSI on 20 August 2022. Available online at: http://npic.orst.edu/ingred/ppdmove.htm.

NPIC. 2011. 2,4-D Technical Fact Sheet. National Pesticide Information Center, Oregon State University. Available online at: http://npic.orst.edu/factsheets/archive/2,4-DTech.html

OPB. 2018. Oregon Bans Tree-Killing Herbicide Amid Sweeping Investigation. Available online at: https://www.opb.org/news/article/oregon-washington-bans-tree-killing-herbicide-investigation/

Oros, D. R. and I. Werner. 2005. Pyrethroid insecticides: an analysis of use patterns, distributions, potential toxicity, and fate in the Sacramento-San Joaquin Delta and Central Valley. White Paper for the Interagency Ecological Program. SFEI Contribution 415. San Francisco Estuary Institute, Oakland, California.

Oliveira Jr., R. S., Koskinen, W.C., Werdin, N.R., and Yen, P.Y. 2000. Sorption of imidacloprid and its metabolites on tropical soils, Journal of Environmental Science and Health, Part B, 35:1, 39-49.

Pers. Comm. 2022. Communication from Kevin Masterson (Stony Creek Consulting) to Matt Kohlbecker (GSI Water Solutions). 18 March 2022.

Pest Management Regulatory Agency of Canada. 2016. Re-evaluation Note REV2016-15, Special Review of Dichlobenil: Proposed Decision for Consultation. Accessed by GSI on 18 August 2022. Available online at: Re-evaluation Note REV2016-15, Special Review of Dichlobenil: Proposed Decision for Consultation - Canada.ca.

PPDB. 2014. Pesticides Properties Database. Available online at: http://sitem.herts.ac.uk/aeru/ppdb/en/

Priester, T. M., 1990. Batch Equilibrium (Adsorption/desorption) and soil thin-layer chromatography studies with [carbonyl-14C] Diuron, E. I. du Pont Nemours & Co Inc., Wilmington, Delaware. Report No. AMR 452-85.

PubChem. 2022. Bifenthrin Compound Summary. Accessed by GSI on 20 August 2022. Available online at: https://pubchem.ncbi.nlm.nih.gov/compound/Bifenthrin.

PubChem. 2022. 4-Nonylphenol Compound Summary. Accessed by GSI on 20 August 2022. Available online at: https://pubchem.ncbi.nlm.nih.gov/compound/4-nonylphenol

PubChem. 2022. Perfluorononanoic Acid Compound Summary. Accessed by GSI on 20 August 2022. Available online at: https://pubchem.ncbi.nlm.nih.gov/compound/67821

PubChem. 2022. Perfluorooctanesulfonic Acid Compound Summary. Accessed by GSI on 20 August 2022. Available online at: https://pubchem.ncbi.nlm.nih.gov/compound/74483

Pukkila, V. 2015. Degradation of 2,6-dichlorobenzonitrile and 2,6-dichlorobenzamide in groundwater sedimentary deposits and topsoil. Department of Environmental Sciences, Faculty of Biological and Environmental Sciences. University of Helsinki, Lahti, Finland.

Reddy, K. N., Singh, M., and A. K. Alvia. 1992. Sorption and leaching of bromacil and simazine in Florida flatwoods soils. Bulletin of Environmental Contaminant Toxicology, Volume 48: 662-670.

Reding, M. A. 2005. Evaluation of the relevance of aminomethylphosphonic acid (AMPA). Seminar on Glyphosate and Water, Monsanto.

RMS Germany. 2013. Renewal assessment report on glyphosate. 18 December 2013. RMS Germany, Co-RMS Slovakia.

Rosenqvist, L., Vestergren, R., Westberg, E., Eliaeson, K., Norstrom, K., Lijeberg, M., Strandberg, J., and M. Rahmberg. 2017. Spridning av hogluorerade amnen I mark fran Stockholm Arlanda Airport. Forutsattningar for berakning av platsspecifika riktvarden for mark. Swedeish Environmental Institute (IVL) in collaborations with Swedavia.

Sannino, F., Filazzola, M. T., Violante, A., and L. Gianfreda. 1996. Adsorption-desorption of simazine on montmorillonite coated by hydroxyl aluminum species. Environmental Science Technology, Volume 33: 4221-4225.

Simpson, B. W. and P. A. Hargreaves, 2001. Pesticide transport in sugar production systems. Natural Resources and Mines, Queensland Government, Indooroopily Brisbane.

Tomlin, C. 1994. The Agrochemicals Desk Reference. 2nd Edition. Lewis Publishers. Boca Raton, Florida.

Vogue, P.A., Kerie, E.A., and Jenkins, J.J. 1994. OSU Extension Pesticide Properties Database. National Pesticide Information Center. Accessed by GSI on 20 August 2022. Available online at: http://npic.orst.edu/ingred/ppdmove.htm

Howard, P.H. 1991. Handbook of environmental fate and exposure data for organic chemicals. Vol. III, Pesticides, Lewis Publ. 684 pp

National Pesticide Information Center. 2011. Fipronil Technical Fact Sheet. Accessed by GSI on 20 August 2022. Available online at: http://npic.orst.edu/factsheets/archive/fiptech.html

National Pesticide Information Center. 2011. Imidacloprid Technical Fact Sheet. Accessed by GSI on 20 August 2022. Available online at: http://npic.orst.edu/factsheets/archive/imidacloprid.html

USGS. 1998. Degradates: a Key to Assessing Herbicide Impacts in Streams. Available online at: https://toxics.usgs.gov/highlights/herbicides_deg_streams.html.

USGS. 2018. Health-Based Screening Levels for Evaluating Water Quality Data. Available online at: https://water.usgs.gov/water-resources/hbsl/. May 31.

Walters. Undated. Environmental Fate of 2,4-Dichlorophenoxyacetic Acid. Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California.

Wauchope, R.D., T.M. Butler, A.G. Hornsby, P.W.M. Augustijn-Beckers, and J.P. Burt. 1992. The SCS/ARS/CES pesticide properties database for environmental decision making. Environmental Contaminant Toxicology Reviews. 123:1-164.

Ying, G. G. and R. S. Kookana, 2001. Sorption of fipronil and its metabolites on soils from south Australia. Journal of Environmental Science and Health B, Volume 36: pp. 545-558.

Zareitalabad, P., Siemens, J., Hamer, M. and W. Amelung. 2013. Perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) in surface waters, sediments, soils and wastewater – A review of concentrations and distribution coefficients. Chemosphere, Volume 91, No. 6: 725-732.

ATTACHMENT A

Emerging Pollutant Scoring Data

Table A.1. Toxicity Scoring (Regulatory Standards in ug/L).

Emerging Pollutant Evaluation.

Pollutant	DEQ Risk-Based Concentration Drinking Water Ingestion Pathway Urban Residential Exposure Scenario	EPA Regional Screening Level Ingestion from Residential Tapwater, Child THQ=1, TR=1E-06	EPA Human Health Benchmarks for Pesticides	USGS Health-Based Screening Level	EPA Maximum Contaminant Level	Other	Toxicity Score
2,4-D	670 ug/L	200 ug/L	--	--	70 ug/L	--	Medium
2,6-dichlorobenzamide (BAM)	--	--	270 ug/L	--	--	--	Low
4-nonylphenol	--	--	--	--	--	20 ug/L (1)	Medium
6PPD quinone	--	--	--	--	--	--	--
Aminomethylphosphonic Acid (AMPA)	--	--	--	--	--	1,000 ug/L (2)	Low
Atrazine	--	60 ug/L	--	--	3 ug/L	--	High
Bifenthrin	--	300 ug/L	210 ug/L	--	--	--	Low
DCOI	--	--	--	--	--	--	--
Diuron	--	40 ug/L	--	2 ug/L	--	--	High
Fipronil	--	--	1 ug/L	--	--	--	High
Glyphosate	--	2,000 ug/L	--	--	700 ug/L	--	Low
Glyphosate Isopropylamine	--	--	--	--	--	--	--
Imidacloprid	--	--	500 ug/L	--	--	--	Low
MCPA	30 ug/L	10 ug/L	--	30 ug/L	--	--	High
PFAS: PFBS	--	6 ug/L	--	--	--	--	High
PFAS: PFHxS	--	0.4 ug/L	--	--	--	--	High
PFAS: PFNA	--	0.06 ug/L	--	--	--	--	High
PFAS: PFOS	--	0.04 ug/L	--	--	--	--	High
PFAS: PFOA	--	0.06 ug/L	--	--	--	--	High
Simazine	--	100 ug/L	--	--	4 ug/L	--	High
Sulfometuron methyl	--	--	--	--	--	1,800 ug/L (3)	Low

Notes:

(1) Minnesota Department of Health Guidance Value for nonylphenols, ingestion by humans through the drinking water pathway
(2) Minnesota Department of Health Guidance Value for AMPA, ingestion by humans through the drinking water pathway
(3) Montana Department of Environmental Quality Human Health Standards for Groundwater
DEQ = Department of Environmental Quality
EPA = Environmental Protection Agency
USGS = United States Geological Survey
ug/L = micrograms per liter
2,4-D = 2,4-Dichlorophenoxyacetic acid
DCOI = 4,5-Dichloro-2-octylisothiazol-3(2H)-one
MCPA = 2-methyl-4-chlorophenoxyacetic acid
PFAS = Perfluoroalkyl and Polyfluoroalkyl Substances
PFBS = Perfluorobutane Sulfonic Acid
PFHxS = Perfluorohexane Sulfonic Acid
PFNA = Perfluorononanoic Acid
PFOA = Perfluorooctanoic Acid
PFOS = Perfluorooctane Sulfonic Acid

Table A.2. Mobility Scoring (Koc Values in Liters per Kilogram).

Emerging Pollutant Evaluation.

Pollutant	Number of Values	Minimum	Median	Maximum	Mobility Score
2,4-D	15	20	124	772	High
2,6-dichlobenzamide (BAM)	9	30	34	54	High
4-nonylphenol	4	3,981	16,009	53,300	Medium
6PPD quinone	5	1,585	8,472	8,710	Medium
Aminomethylphosphonic Acid (AMPA)	5	1,160	9,749	25,000	Medium
Atrazine	48	52	246	2,399	High
Bifenthrin	10	8,387	150,144	240,000	Low
DCOI	5	1,585	74,550	2,290,868	Low
Diuron	44	20	591	5,240	High
Fipronil	32	58	336	2,023	High
Glyphosate	17	0.002	4,871	56,741	Medium
Glyphosate Isopropylamine	2	2,080	13,040	24,000	Medium
Imidacloprid	29	71	225	1560	High
MCPA	29	11	29	270	High
PFAS: PFBS	16	0.20	49	1,585	High
PFAS: PFHxS	22	14	251	31,623	High
PFAS: PFNA	26	4	1,395	251,189	Medium
PFAS: PFOS	46	29	684	50,118	High
PFAS: PFOA	37	1	389	100,000	High
Simazine	19	16	95	1,700	High
Sulfometuron methyl	11	18	85	160	High

Notes:

Koc = Organic Carbon Water Partitioning Coefficient
2,4-D = 2,4-Dichlorophenoxyacetic acid
DCOI = 4,5-Dichloro-2-octylisothiazol-3(2H)-one
MCPA = 2-methyl-4-chlorophenoxyacetic acid
PFAS = Perfluoroalkyl and Polyfluoroalkyl Substances

PFBS = Perfluorobutane Sulfonic Acid
PFHxS = Perfluorohexane Sulfonic Acid
PFNA = Perfluorononanoic Acid
PFOA = Perfluorooctanoic Acid
PFOS = Perfluorooctane Sulfonic Acid

Table A.3. Persistence Scoring (Half-Life Values in Days).

Emerging Pollutant Evaluation.

Pollutant	Number of Values	Minimum	Median	Maximum	Persistence Score
2,4-D	3	10	59.3	66	Medium
2,6-dichlobenzamide (BAM)	3	Weeks	Months	Years	Medium
4-nonylphenol	2	1	50	99	Medium
6PPD quinone	3	38	75	337	Medium
Aminomethylphosphonic Acid (AMPA)	6	35	66	98	Medium
Atrazine	1	60	60	60	Medium
Bifenthrin	3	26	65	125	Medium
DCOI	1	4.8	4.8	4.8	Low
Diuron	11	20	90	90	Medium
Fipronil	14	31	119	1,378	Medium
Glyphosate	14	1.8	18	151	Low
Glyphosate Isopropylamine	3	1.9	2.1	47	Low
Imidacloprid	1	997	997	997	High
MCPA	2	7	24	41	Low
PFAS: PFBS	--	--	--	--	
PFAS: PFHxS	--	--	--	--	--
PFAS: PFNA	--	--	--	--	--
PFAS: PFOS	1	>14,965	>14,965	>14,965	High
PFAS: PFOA	1	>33,580	>33,580	>33,580	High
Simazine	1	60	60	60	Medium
Sulfometuron methyl	1	20	20	20	Low

Notes:

2,4-D = 2,4-Dichlorophenoxyacetic acid
DCOI = 4,5-Dichloro-2-octylisothiazol-3(2H)-one
MCPA = 2-methyl-4-chlorophenoxyacetic acid
PFAS = Perfluoroalkyl and Polyfluoroalkyl Substances
PFBS = Perfluorobutane Sulfonic Acid
PFHxS = Perfluorohexane Sulfonic Acid
PFNA = Perfluorononanoic Acid
PFOA = Perfluorooctanoic Acid
PFOS = Perfluorooctane Sulfonic Acid

Table A.4. Pollutant Concentration Statistics.
Emerging Pollutant Evaluation.

Pollutant	Number of Samples	Minimum Concentration (ug/L)	Median Concentration (ug/L)	Average Concentration (ug/L)	Maximum Concentration (ug/L)	Number of Detections	Percent Detection	Lowest Regulatory Standard	Number of Exceedances of Lowest Regulatory Standard	Exceedance Frequency
2,4-D	2,051	0.028	0.1	0.88	32.3	347	16.9%	MCL (70 ug/L)	0	0%
2,6-dichlobenzamide (BAM)	283	0.0213	0.128	0.20	0.986	249	88.0%	EPA HHBP, Chronic or Lifetime (270 ug/L)	0	0%
4-nonylphenol	-	-	-	-	-	-	-	Minnesota Department of Health (20 ug/L)	No data	No data
6PPD quinone	2	0.137	0.419	0.42	0.701	2	100.0%	-	NA	NA
Aminomethylphosphonic Acid (AMPA)	92	0.05	0.471	3.54	10	51	55.4%	Minnesota Department of Health (1000 ug/L)	0	0%
Atrazine	917	0.002	0.0096	0.0290	0.3	59	6.4%	MCL (3 ug/L)	0	0%
Bifenthrin	498	0.0185	0.038	0.0583	0.313	10	2.0%	EPA HHBP, Acute or One Day (210 ug/L)	0	0%
DCOI	-	-	-	-	-	-	-	Predicted No-Effect Concentration (0.06 ug/L)	No data	No data
Diuron	581	0.002	0.0202	0.14	6.92	380	65.4%	USGS HBSL, Cancer (2 ug/L)	8	1.4%
Fipronil	43	0.0061	0.6	0.37	0.6	8	18.6%	EPA HHBP, Chronic or Lifetime (1 ug/L)	0	0%
Glyphosate	160	0.05	6	5.40	27	39.0	24.4%	MCL (700 ug/L)	0	0%
Imidacloprid	535	0.01	0.0216	0.0430	0.795	64	12.0%	EPA HHBP, Chronic or Lifetime (360 ug/L)	0	0%
MCPA	440	0.04	1.24	9.89	101	5	1.1%	EPA Regional Screening Level, Ingestion SL Child THQ = 1.0 (Noncancer) (10 ug/L)	218	50%
Simazine	922	0.002	0.024	0.0426	1.3	341	37.0%	EPA Regional Screening Level, Ingestion SL Child THQ = 1.0 (Noncancer) (0.65 ug/L)	2	0.2%
Sulfometuron methyl	394	0.0037	0.00438	0.0238	1.09	90	22.8%	Montana Department of Environmental Quality (1800 ug/L)	0	0%
PFAS: PFBS	10	0.0003	0.000955	0.0016	0.0044	10	100.0%	EPA Regional Screening Level, Ingestion SL Child THQ = 1.0 (Noncancer) (6 ug/L)	0	0.00%
PFAS: PFHxS	10	0.0013	0.00185	0.0029	0.006	5	50.0%	EPA Regional Screening Level, Ingestion SL Child THQ = 1.0 (Noncancer) (0.4 ug/L)	0	0.00%
PFAS: PFNA	10	0.0011	0.0011	0.0018	0.0039	4	40.0%	EPA Regional Screening Level, Ingestion SL Child THQ = 1.0 (Noncancer) (0.06 ug/L)	0	0.00%
PFAS: PFOS	10	0.0015	0.00655	0.0102	0.023	10	100.0%	EPA Regional Screening Level, Ingestion SL Child THQ = 1.0 (Noncancer) (0.040 ug/L)	0	0.00%
PGAS: PFOA	10	0.00084	0.00245	0.0051	0.017	10	100.0%	EPA Regional Screening Level, Ingestion SL Child THQ = 1.0 (Noncancer) (0.060 ug/L)	0	0.00%

Notes:
2,4-D = 2,4-Dichlorophenoxyacetic acid
DCOI = 4,5-Dichloro-2-octylisothiazol-3(2H)-one
EPA = Environmental Protection Agency
HBSL = Health-Based Screening Level
HHBP = Human Health Benchmarks for Pesticides
MCPA = 2-methyl-4-chlorophenoxyacetic acid
PFAS = Perfluoroalkyl and Polyfluoroalkyl Substances
PFBS = Perfluorobutane Sulfonic Acid
PFHxS = Perfluorohexane Sulfonic Acid
PFNA = Perfluorononanoic Acid
PFOA = Perfluorooctanoic Acid
PFOS = Perfluorooctane Sulfonic Acid
SL = screening level
THQ = target hazard quotient
ug/L = micrograms per liter
USGS = United States Geological Survey

ATTACHMENT B

Individual K_{oc} and Half Life Values for Emerging Pollutants

Table B.1. Koc Values.

Emerging Pollutant Evaluation.

Emerging Pollutant	Description	Koc Value	Units	Source
2,4-D	Acid: Sorption Coefficient (soil Koc)	20	L/Kg	OSU Extension Pesticide Properties Database (orst.edu)
2,4-D	Acid: Sorption Coefficient (soil Koc)	136	L/Kg	OSU Extension Pesticide Properties Database (orst.edu)
2,4-D	Acid: Sorption Coefficient (soil Koc)	19.6	L/Kg	EPA (1995) 2,4-D National Primary Drinking Water Regulations fact sheet
2,4-D	Acid: Sorption Coefficient (soil Koc)	109.1	L/Kg	EPA (1995) 2,4-D National Primary Drinking Water Regulations fact sheet
2,4-D	Acid: Sorption Coefficient (soil Koc)	61.13	L/Kg	Meftaul et al (2020)
2,4-D	Acid: Sorption Coefficient (soil Koc)	112.95	L/Kg	Meftaul et al (2020)
2,4-D	Acid: Sorption Coefficient (soil Koc)	771.59	L/Kg	Meftaul et al (2020)
2,4-D	Acid: Sorption Coefficient (soil Koc)	263.27	L/Kg	Meftaul et al (2020)
2,4-D	Acid: Sorption Coefficient (soil Koc)	87.34	L/Kg	Meftaul et al (2020)
2,4-D	Acid: Sorption Coefficient (soil Koc)	665.31	L/Kg	Meftaul et al (2020)
2,4-D	Acid: Sorption Coefficient (soil Koc)	256.31	L/Kg	Meftaul et al (2020)
2,4-D	Acid: Sorption Coefficient (soil Koc)	256.03	L/Kg	Meftaul et al (2020)
2,4-D	Acid: Sorption Coefficient (soil Koc)	106.8	L/Kg	Meftaul et al (2020)
2,4-D	Acid: Sorption Coefficient (soil Koc)	135.15	L/Kg	Meftaul et al (2020)
2,4-D	Minimum	20	L/Kg	
	Median	124	L/Kg	
	Maximum	772	L/Kg	
2,6-dichlobenzamide (BAM)	Koc low	34	L/Kg	Special Review of Dichlobenil
2,6-dichlobenzamide (BAM)	Koc high	54	L/Kg	Special Review of Dichlobenil
2,6-dichlobenzamide (BAM)	Koc low	30	L/Kg	HSDB
2,6-dichlobenzamide (BAM)	Koc high	33	L/Kg	Holtze et al (2008)
2,6-dichlobenzamide (BAM)	Koc low	35	L/Kg	Holtze et al (2008)
2,6-dichlobenzamide (BAM)	Koc high	34	L/Kg	EPA (2012)
2,6-dichlobenzamide (BAM)	Koc low	54	L/Kg	EPA (2012)
2,6-dichlobenzamide (BAM)	Minimum	30	L/Kg	
	Median	34	L/Kg	
	Maximum	54	L/Kg	
4-nonylphenol	low	6900	L/Kg	4-Nonylphenol | C15H24O - PubChem (nih.gov)
4-nonylphenol	high	53300	L/Kg	4-Nonylphenol | C15H24O - PubChem (nih.gov)
4-nonylphenol (general)	Koc in soil	3981	L/Kg	Nonylphenols Tier II Assessment
4-nonylphenol (general)	calculated from log Kow = 4.48. Nonionisable in environment.	25119	L/Kg	Nonylphenols Tier II Assessment
4-nonylphenol	Minimum	3,981	L/Kg	
	Median	16,009	L/Kg	
	Maximum	53,300	L/Kg	
6PPD quinone	Koc	8589	L/Kg	2022_SWTreatmentOfTireContaminants-BMPEffectiveness.pdf (wa.gov)
6PPD quinone	Koc	8710	L/Kg	2022_SWTreatmentOfTireContaminants-BMPEffectiveness.pdf (wa.gov)
6PPD quinone		8472	L/Kg	CalEPA (2021)

Emerging Pollutant	Description	Koc Value	Units	Source
6PPD quinone	Koc	1585	L/Kg	Hiki and Yamamoto (2022)
6PPD quinone	Koc	3162	L/Kg	Hiki and Yamamoto (2022)
6PPD quinone	Minimum	1585	L/Kg	
	Median	8472	L/Kg	
	Maximum	8710	L/Kg	
AMPA	Koc low	1160	L/Kg	Glyphosate and AMPA behavior...
AMPA	Koc high	24800	L/Kg	Glyphosate and AMPA behavior...
AMPA	Koc	9749	L/Kg	RMS Germany (2013).
AMPA	Koc	1200	L/Kg	Reding (2005)
AMPA	Koc	25000	L/Kg	Reding (2005)
AMPA	Minimum	1160	L/Kg	
	Median	9749	L/Kg	
	Maximum	25000	L/Kg	
Atrazine	Koc	91	L/Kg	ATSDR Profile
Atrazine	Koc	93	L/Kg	ATSDR Profile
Atrazine	Koc	151	L/Kg	ATSDR Profile
Atrazine	Koc	214	L/Kg	ATSDR Profile
Atrazine	Koc	339	L/Kg	ATSDR Profile
Atrazine	Koc	955	L/Kg	ATSDR Profile
Atrazine	Koc	2399	L/Kg	ATSDR Profile
Atrazine	Sorption Coefficient (soil Koc)	100	L/Kg	OSU Extension Pesticide Properties Database (orst.edu)
Atrazine	Sorption Coefficient (soil Koc)	440	L/Kg	Mersie and Seybold (1996)
Atrazine	Sorption Coefficient (soil Koc)	109	L/Kg	Dousset et al. (1994)
Atrazine	Sorption Coefficient (soil Koc)	100	L/Kg	Wauchope et al. (1992)
Atrazine	Skunk River Site 1, 0 - 25 cm	163	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 1, 50 - 75 cm	346	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 1, 160 - 180 cm	255	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 1, 235 - 260 cm	440	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 1, 300 - 325 cm	558	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 1, 350 - 375 cm	459	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 2, 0 - 25 cm	153	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 2, 50 - 75 cm	213	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 2, 150 - 175 cm	112	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 2, 235 - 260 cm	150	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 2, 300 - 325 cm	370	L/Kg	Moorman et al. (2001)
Atrazine	Skunk River Site 2, 350 - 375 cm	563	L/Kg	Moorman et al. (2001)
Atrazine	Treynor Monona Soil, 0 - 25 cm	145	L/Kg	Moorman et al. (2001)
Atrazine	Treynor Monona Soil, 50 - 100 cm	165	L/Kg	Moorman et al. (2001)
Atrazine	Treynor Monona Soil, 150 - 200 cm	88	L/Kg	Moorman et al. (2001)
Atrazine	Treynor Monona Soil, 250 - 300 cm	386	L/Kg	Moorman et al. (2001)
Atrazine	Ida Soil, 0 - 25 cm	169	L/Kg	Moorman et al. (2001)

Emerging Pollutant	Description	Koc Value	Units	Source
Atrazine	Ida Soil, 50 - 100 cm	236	L/Kg	Moorman et al. (2001)
Atrazine	Ida Soil, 150 - 200 cm	511	L/Kg	Moorman et al. (2001)
Atrazine	Ida Soil, 250 - 300 cm	678	L/Kg	Moorman et al. (2001)
Atrazine	Walnut Creek Clarion Soil, 0 - 25 cm	216	L/Kg	Moorman et al. (2001)
Atrazine	Walnut Creek Clarion Soil, 40 - 110 cm	138	L/Kg	Moorman et al. (2001)
Atrazine	Walnut Creek Clarion Soil, 140 - 210 cm	52	L/Kg	Moorman et al. (2001)
Atrazine	Walnut Creek Clarion Soil, 320 - 335 cm	1021	L/Kg	Moorman et al. (2001)
Atrazine	Walnut Creek Clarion Soil, 604 - 619 cm	1588	L/Kg	Moorman et al. (2001)
Atrazine	Nicollet Soil, 0 - 25 cm	230	L/Kg	Moorman et al. (2001)
Atrazine	Nicollet Soil, 40 - 110 cm	154	L/Kg	Moorman et al. (2001)
Atrazine	Nicollet Soil, 140 - 210 cm	512	L/Kg	Moorman et al. (2001)
Atrazine	Okoboji Soil, 0 - 25 cm	332	L/Kg	Moorman et al. (2001)
Atrazine	Okoboji Soil, 40 - 110 cm	258	L/Kg	Moorman et al. (2001)
Atrazine	Nashua, 0 - 15 cm	187	L/Kg	Moorman et al. (2001)
Atrazine	Nashua, 100 - 115 cm	485	L/Kg	Moorman et al. (2001)
Atrazine	Nashua, 232 - 244 cm	750	L/Kg	Moorman et al. (2001)
Atrazine	Nashua, 488 - 503 cm	100	L/Kg	Moorman et al. (2001)
Atrazine	Nashua, 786 - 820 cm	546	L/Kg	Moorman et al. (2001)
Atrazine	Nashua, 1186 - 1189 cm	567	L/Kg	Moorman et al. (2001)
Atrazine	Nashua, 1189 - 1219	2094	L/Kg	Moorman et al. (2001)
Atrazine	Minimum	52	L/Kg	
	Median	246	L/Kg	
	Maximum	2399	L/Kg	
Bifenthrin	Sorption Coefficient (soil Koc)	240,000	L/Kg	OSU Extension Pesticide Properties Database (orst.edu)
Bifenthrin	Sorption Coefficient (soil Koc)	14,332	L/Kg	PubChem (2022)
Bifenthrin	Sorption Coefficient (soil Koc)	8,695	L/Kg	PubChem (2022)
Bifenthrin	Sorption Coefficient (soil Koc)	8,387	L/Kg	PubChem (2022)
Bifenthrin	Sorption Coefficient (soil Koc)	131,000	L/Kg	Fecko (1999)
Bifenthrin	Sorption Coefficient (soil Koc)	302,000	L/Kg	Fecko (1999)
Bifenthrin	Sorption Coefficient (soil Koc)	148,094	L/Kg	PubChem (2022)
Bifenthrin	Sorption Coefficient (soil Koc)	152,193	L/Kg	PubChem (2022)
Bifenthrin	Sorption Coefficient (soil Koc)	2,290,868	L/Kg	EPA (2016)
Bifenthrin	Sorption Coefficient (soil Koc)	251,189	L/Kg	Oros et al. (2005)
Bifenthrin	Minimum	8387	L/Kg	
	Median	150144	L/Kg	
	Maximum	2290868	L/Kg	
DCOI	adsorption/desorption; 0.2-4.4% OC; low	1691	L/Kg	DCOIT Final Work Plan
DCOI	adsorption/desorption; 0.2-4.4% OC; high	7865	L/Kg	DCOIT Final Work Plan
DCOI	adsorption/desorption; 4.1-5% OC; low	15441	L/Kg	DCOIT Final Work Plan
DCOI	adsorption/desorption; 4.1-5% OC; high	18100	L/Kg	DCOIT Final Work Plan
DCOI	Log Koc = 3.2	1585	L/Kg	Sea-Nine fact sheet

Emerging Pollutant	**Description**	**Koc Value**	**Units**	**Source**
DCOI	Minimum	1,585	L/Kg	
	Median	74,550	L/Kg	
	Maximum	2,290,868	L/Kg	
Diuron	Sorption Coefficient (soil Koc)	480	L/Kg	OSU Extension Pesticide Properties Database (orst.edu)
Diuron	Sorption Coefficient (soil Koc)	259	L/Kg	Kasozi et al. (2010)
Diuron	Sorption Coefficient (soil Koc)	558	L/Kg	Kasozi et al. (2010)
Diuron	Sorption Coefficient (soil Koc)	973	L/Kg	Kasozi et al. (2010)
Diuron	Sorption Coefficient (soil Koc)	2,090	L/Kg	Kasozi et al. (2010)
Diuron	Sorption Coefficient (soil Koc)	1,666	L/Kg	Bramble et al. (1998)
Diuron	Sorption Coefficient (soil Koc)	468	L/Kg	Bramble et al. (1998)
Diuron	Sorption Coefficient (soil Koc)	626	L/Kg	Bramble et al. (1998)
Diuron	Sorption Coefficient (soil Koc)	452	L/Kg	Priester (1990)
Diuron	Sorption Coefficient (soil Koc)	418	L/Kg	Priester (1990)
Diuron	Sorption Coefficient (soil Koc)	574	L/Kg	Priester (1990)
Diuron	Sorption Coefficient (soil Koc)	487	L/Kg	Priester (1990)
Diuron	Sorption Coefficient (soil Koc)	1,326	L/Kg	Simpson and Hargreaves (2001)
Diuron	Sorption Coefficient (soil Koc)	3,738	L/Kg	Simpson and Hargreaves (2001)
Diuron	Sorption Coefficient (soil Koc)	2,244	L/Kg	Simpson and Hargreaves (2001)
Diuron	Sorption Coefficient (soil Koc)	5,240	L/Kg	Simpson and Hargreaves (2001)
Diuron	Sorption Coefficient (soil Koc)	507	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	884	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	598	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	918	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	556	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	762	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	459	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	583	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	473	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	679	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	477	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	678	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	428	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	707	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	452	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	479	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	405	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	547	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	538	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	975	L/Kg	Ahangar et al. (2008)
Diuron	Sorption Coefficient (soil Koc)	145	L/Kg	Dores et al. (2009)
Diuron	Sorption Coefficient (soil Koc)	917	L/Kg	Dores et al. (2009)

Emerging Pollutant	Description	Koc Value	Units	Source
Diuron	Sorption Coefficient (soil Koc)	636	L/Kg	Nkedi-Kizza et al., (1983)
Diuron	Sorption Coefficient (soil Koc)	570	L/Kg	Nkedi-Kizza et al., (1983)
Diuron	Sorption Coefficient (soil Koc)	884	L/Kg	Nkedi-Kizza et al., (1983)
Diuron	Sorption Coefficient (soil Koc)	619	L/Kg	Nkedi-Kizza et al., (1983)
Diuron	Sorption Coefficient (soil Koc)	706	L/Kg	Nkedi-Kizza et al., (1983)
Diuron	Sorption Coefficient (soil Koc)	733	L/Kg	Nkedi-Kizza et al., (1983)
Diuron	Minimum	145	L/Kg	
	Median	591	L/Kg	
	Maximum	5,240	L/Kg	
Fipronil	Soil Sorption Coefficient (Koc); low	214	L/Kg	Fipronil Technical Fact Sheet (orst.edu)
Fipronil	Soil Sorption Coefficient (Koc); high	825	L/Kg	Fipronil Technical Fact Sheet (orst.edu)
Fipronil	Koc	427	L/Kg	Godward et al. (1996)
Fipronil	Koc	1248	L/Kg	Godward et al. (1996)
Fipronil	Koc	486	L/Kg	Godward et al. (1996)
Fipronil	Koc	800	L/Kg	Godward et al. (1996)
Fipronil	Koc	673	L/Kg	Godward et al. (1996)
Fipronil	Koc	278	L/Kg	Ying and Kookana (2001)
Fipronil	Koc	290	L/Kg	Ying and Kookana (2001)
Fipronil	Koc	546	L/Kg	Ying and Kookana (2001)
Fipronil	Koc	268	L/Kg	Ying and Kookana (2001)
Fipronil	Koc	410	L/Kg	Ying and Kookana (2001)
Fipronil	Koc	380	L/Kg	Ying and Kookana (2001)
Fipronil	Koc	254	L/Kg	Ying and Kookana (2001)
Fipronil	Koc	369	L/Kg	Ying and Kookana (2001)
Fipronil	Koc	320	L/Kg	Doran et al. (2006)
Fipronil	Koc	292	L/Kg	Doran et al. (2006)
Fipronil	Koc	116	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	58	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	70	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	65	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	72	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	2023	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	1452	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	1642	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	1500	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	1428	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	351	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	234	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	192	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	149	L/Kg	Mukerjee and Kalpana (2006)
Fipronil	Koc	150	L/Kg	Mukerjee and Kalpana (2006)

Emerging Pollutant	Description	Koc Value	Units	Source
Fipronil	Minimum	58	L/Kg	
	Median	336	L/Kg	
	Maximum	2,023	L/Kg	
Glyphosate	Koc high	2080	L/Kg	ATSDR Profile
Glyphosate	Koc high	4,900	L/Kg	ATSDR Profile
Glyphosate	Koc low	0.0017	L/Kg	ATSDR Profile
Glyphosate	Koc low	2,600	L/Kg	ATSDR Profile
Glyphosate	Koc	15,844	L/Kg	RMS Germany (2013)
Glyphosate	Koc	24,000	L/Kg	Monsanto (2005)
Glyphosate	Koc	1,099	L/Kg	Montgomery and Crompton (2018)
Glyphosate	Koc	4,871	L/Kg	Montgomery and Crompton (2018)
Glyphosate	Koc	554	L/Kg	Montgomery and Crompton (2018)
Glyphosate	Koc	33,967	L/Kg	Montgomery and Crompton (2018)
Glyphosate	Koc	3,414	L/Kg	Montgomery and Crompton (2018)
Glyphosate	Koc	2,661	L/Kg	Montgomery and Crompton (2018)
Glyphosate	Kurosol - Unifarm	1169	L/Kg	Doyle et al (2008)
Glyphosate	Vertosol - Unifarm	26622	L/Kg	Doyle et al (2008)
Glyphosate	Ferrosol - Huon	52081	L/Kg	Doyle et al (2008)
Glyphosate	Ferrosol - Northdown	56741	L/Kg	Doyle et al (2008)
Glyphosate	Dermosol (Pyengana)	33698	L/Kg	Doyle et al (2008)
Glyphosate	Minimum	0	L/Kg	
	Median	4871	L/Kg	
	Maximum	56741	L/Kg	
Glyphosate isopropylamine	isopropylamine salt: Sorption Coefficient (soil Koc)	24,000	L/Kg	OSU Extension Pesticide Properties Database (orst.edu)
Glyphosate isopropylamine	Koc	2080	L/Kg	ATSDR Profile
Glyphosate Isopropylamine	Minimum	2,080	L/Kg	
	Median	13,040	L/Kg	
	Maximum	24,000	L/Kg	
Imidacloprid	Soil Sorption Coefficient (Koc) range; low	156	L/Kg	Imidacloprid Technical Fact Sheet (orst.edu)
Imidacloprid	Soil Sorption Coefficient (Koc) range; high	960	L/Kg	Imidacloprid Technical Fact Sheet (orst.edu)
Imidacloprid	Soil Sorption Coefficient (Koc) range; low	132	L/Kg	Environmental Fate of Imidacloprid
Imidacloprid	Soil Sorption Coefficient (Koc) range; high	310	L/Kg	Environmental Fate of Imidacloprid
Imidacloprid	Sand, pH=5.1	411	L/Kg	EFSA (2008)
Imidacloprid	Sandy soil low humus, pH=5.6	157	L/Kg	EFSA (2008)
Imidacloprid	Sandy loam, pH=5.2	256	L/Kg	EFSA (2008)
Imidacloprid	Sandy loam, pH=5.7	153	L/Kg	EFSA (2008)
Imidacloprid	Sandy loam, pH=6.4	235	L/Kg	EFSA (2008)
Imidacloprid	Sandy loam, pH=6.4	109	L/Kg	EFSA (2008)
Imidacloprid	Sandy loam, pH=5.6	165	L/Kg	EFSA (2008)
Imidacloprid	Loamy sand, pH=4.5	292	L/Kg	EFSA (2008)
Imidacloprid	Silt loam, pH=5.8	277	L/Kg	EFSA (2008)

Emerging Pollutant	Description	Koc Value	Units	Source
Imidacloprid	Silt soil, pH=5.3	132	L/Kg	EFSA (2008)
Imidacloprid	Silty clay, pH=7.4	212	L/Kg	EFSA (2008)
Imidacloprid	Loam, pH=6.5	296	L/Kg	EFSA (2008)
Imidacloprid	Koc	225	L/Kg	PPDB (2014)
Imidacloprid	Silt Loam	78	L/Kg	Cox et al (1997)
Imidacloprid	Silt Loam	802	L/Kg	Cox et al (1997)
Imidacloprid	Clay Loam	81	L/Kg	Cox et al (1997)
Imidacloprid	Clay Loam	1560	L/Kg	Cox et al (1997)
Imidacloprid	Sandy Loam	71	L/Kg	Cox et al (1997)
Imidacloprid	Sandy Loam	893	L/Kg	Cox et al (1997)
Imidacloprid	Loamy Sand	799	L/Kg	Oliveria et al (2010)
Imidacloprid	Clay	158	L/Kg	Oliveria et al (2010)
Imidacloprid	Clay	186	L/Kg	Oliveria et al (2010)
Imidacloprid	Sand	203	L/Kg	Oliveria et al (2010)
Imidacloprid	Sandy Loam	227	L/Kg	Oliveria et al (2010)
Imidacloprid	Sandy Clay Loam	620	L/Kg	Oliveria et al (2010)
Imidacloprid	Minimum	71	L/Kg	
	Median	225	L/Kg	
	Maximum	1560	L/Kg	
MCPA	low	54	L/Kg	A review of the pesticide MCPA in the land-water environment and emerging research needs
MCPA	high	118	L/Kg	A review of the pesticide MCPA in the land-water environment and emerging research needs
MCPA	A1, initial concentration 10 mg/L	20.9	L/Kg	Hiller et al (2006)
MCPA	A2, initial concentration 10 mg/L	25.9	L/Kg	Hiller et al (2006)
MCPA	A3, initial concentration 10 mg/L	14.7	L/Kg	Hiller et al (2006)
MCPA	A4, initial concentration 10 mg/L	15.1	L/Kg	Hiller et al (2006)
MCPA	A5, initial concentration 10 mg/L	16.5	L/Kg	Hiller et al (2006)
MCPA	S1, initial concentration 10 mg/L	26.6	L/Kg	Hiller et al (2006)
MCPA	S2, initial concentration 10 mg/L	26.6	L/Kg	Hiller et al (2006)
MCPA	S3, initial concentration 10 mg/L	37.4	L/Kg	Hiller et al (2006)
MCPA	L1, initial concentration 10 mg/L	28.6	L/Kg	Hiller et al (2006)
MCPA	L2, initial concentration 10 mg/L	16.3	L/Kg	Hiller et al (2006)
MCPA	SS, initial concentration 10 mg/L	12.9	L/Kg	Hiller et al (2006)
MCPA	A1, initial concentration 0.5 mg/L	24	L/Kg	Hiller et al (2006)
MCPA	A2, initial concentration 0.5 mg/L	20.5	L/Kg	Hiller et al (2006)
MCPA	A3, initial concentration 0.5 mg/L	19.4	L/Kg	Hiller et al (2006)
MCPA	A4, initial concentration 0.5 mg/L	32.7	L/Kg	Hiller et al (2006)
MCPA	A5, initial concentration 0.5 mg/L	32.4	L/Kg	Hiller et al (2006)
MCPA	S1, initial concentration 0.5 mg/L	41.9	L/Kg	Hiller et al (2006)
MCPA	S2, initial concentration 0.5 mg/L	17.1	L/Kg	Hiller et al (2006)
MCPA	S3, initial concentration 0.5 mg/L	44.3	L/Kg	Hiller et al (2006)
MCPA	L2, initial concentration 0.5 mg/L	11.1	L/Kg	Hiller et al (2006)

Emerging Pollutant	**Description**	**Koc Value**	**Units**	**Source**
MCPA	SS, initial concentration 0.5 mg/L	35.1	L/Kg	Hiller et al (2006)
MCPA	Kurosol - Unifarm	91	L/kg	Doyle et al (2008)
MCPA	Vertosol - Unifarm	72	L/kg	Doyle et al (2008)
MCPA	Vertosol2 - Unifarm	44	L/kg	Doyle et al (2008)
MCPA	Ferrosol - Huon	165	L/kg	Doyle et al (2008)
MCPA	Ferrosol - Northdown	120	L/kg	Doyle et al (2008)
MCPA	Dermosol - Pyengana	270	L/kg	Doyle et al (2008)
MCPA	Minimum	11	L/Kg	
	Median	29	L/Kg	
	Maximum	270	L/Kg	
Perfluorobutane-sulfonic Acid (PFBS)	Koc average	115	L/Kg	ATSDR Profile
Perfluorobutane-sulfonic Acid (PFBS)	Perfluorobutane-sulfonic Acid (PFBS) - Koc	182	L/Kg	NGWA_PFAS_document
Perfluorobutane-sulfonic Acid (PFBS)		10	L/Kg	Geosyntec (2019)
Perfluorobutane-sulfonic Acid (PFBS)		17	L/Kg	Milinovic et al (2015)
Perfluorobutane-sulfonic Acid (PFBS)		62	L/Kg	Guelfo and Higgins (2013)
Perfluorobutane-sulfonic Acid (PFBS)	Soil	0.20	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Soil	1.20	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Soil	0.20	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Soil	158	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Sediment	56	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Sediment	123	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Soil	355	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Sediment & Suspended Particulate Matter	42	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Sediment	6	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Sediment	1	L/Kg	ITRC (2022)
Perfluorobutane-sulfonic Acid (PFBS)	Sediment	1585	L/Kg	ITRC (2022)
PFBS	Minimum	0.20	L/Kg	
	Median	49	L/Kg	
	Maximum	1,585	L/Kg	
Perfluorohexane-sulfonic Acid (PFHxS)	Perfluorohexane-sulfonic Acid (PFHxS) - Koc	60	L/Kg	NGWA_PFAS_document
Perfluorohexane-sulfonic Acid (PFHxS)	Soil	112	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Soil	50	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Soil	12589	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	105	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	138	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Soil	457	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment & Suspended Particulate Matter	191	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment & Suspended Particulate Matter	195	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment & Suspended Particulate Matter	3981	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment & Suspended Particulate Matter	5012	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	14	L/Kg	ITRC (2022)

Emerging Pollutant	Description	Koc Value	Units	Source
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	16	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	316	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	794	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	1000	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	251	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	12589	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	5012	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	158	L/Kg	ITRC (2022)
Perfluorohexane-sulfonic Acid (PFHxS)	Sediment	31623	L/Kg	ITRC (2022)
PFHxS	Minimum	14.13	L/Kg	
	Median	251	L/Kg	
	Maximum	31,623	L/Kg	
Perfluorononanoic Acid (PFNA)	Koc	245	L/Kg	ATSDR Profile
Perfluorononanoic Acid (PFNA)	Perfluorononanoic Acid (PFNA) - Koc	120226	L/Kg	NGWA_PFAS_document
Perfluorononanoic Acid (PFNA)	Perfluorononanoic Acid (PFNA) - Koc	120000	L/Kg	PubChem
Perfluorononanoic Acid (PFNA)		245	L/Kg	Geosyntec (2019)
Perfluorononanoic Acid (PFNA)	Sediment	316	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Soil	4	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Soil	79	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Soil	229	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Soil	251	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Soil	7943	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	224	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	316	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	4898	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Soil	3981	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment & Suspended Particulate Matter	5129	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment & Suspended Particulate Matter	7413	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment & Suspended Particulate Matter	251	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment & Suspended Particulate Matter	10000	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	1995	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	3981	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	10000	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	251189	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	39811	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	794	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	676	L/Kg	ITRC (2022)
Perfluorononanoic Acid (PFNA)	Sediment	562	L/Kg	ITRC (2022)
PFNA	Minimum	4	L/Kg	
	Median	1,395	L/Kg	
	Maximum	251,189	L/Kg	

Emerging Pollutant	Description	Koc Value	Units	Source
Perfluorooctane-sulfonic Acid (PFOS)	low	250	L/Kg	PubChem
Perfluorooctane-sulfonic Acid (PFOS)	high	50100	L/Kg	PubChem
Perfluorooctane-sulfonic Acid (PFOS)	Koc average	1000	L/Kg	PubChem
Perfluorooctane-sulfonic Acid (PFOS)	Koc average	1380	L/Kg	ATSDR Profile
Perfluorooctane-sulfonic Acid (PFOS)	low	251.2	L/Kg	NGWA_PFAS_document
Perfluorooctane-sulfonic Acid (PFOS)	high	50118	L/Kg	NGWA_PFAS_document
Perfluorooctane-sulfonic Acid (PFOS)		1400	L/Kg	Chen et al. (2013)
Perfluorooctane-sulfonic Acid (PFOS)		676	L/Kg	Chen et al. (2013)
Perfluorooctane-sulfonic Acid (PFOS)		644	L/Kg	Chen et al. (2013)
Perfluorooctane-sulfonic Acid (PFOS)		775	L/Kg	Chen et al. (2013)
Perfluorooctane-sulfonic Acid (PFOS)		718.75	L/Kg	Chen et al. (2013)
Perfluorooctane-sulfonic Acid (PFOS)		9500	L/Kg	Milinovic et al. (2015)
Perfluorooctane-sulfonic Acid (PFOS)		2000	L/Kg	Milinovic et al. (2015)
Perfluorooctane-sulfonic Acid (PFOS)		974	L/Kg	Milinovic et al. (2015)
Perfluorooctane-sulfonic Acid (PFOS)		987	L/Kg	Milinovic et al. (2015)
Perfluorooctane-sulfonic Acid (PFOS)		1170	L/Kg	Milinovic et al. (2015)
Perfluorooctane-sulfonic Acid (PFOS)		756	L/Kg	Milinovic et al. (2015)
Perfluorooctane-sulfonic Acid (PFOS)		1500	L/Kg	Enevoldsen and Juhler (2010)
Perfluorooctane-sulfonic Acid (PFOS)		4048	L/Kg	Enevoldsen and Juhler (2010)
Perfluorooctane-sulfonic Acid (PFOS)		692	L/Kg	Higgins and Luthy (2006)
Perfluorooctane-sulfonic Acid (PFOS)		178	L/Kg	Higgins and Luthy (2006)
Perfluorooctane-sulfonic Acid (PFOS)		328	L/Kg	Higgins and Luthy (2006)
Perfluorooctane-sulfonic Acid (PFOS)		474	L/Kg	Higgins and Luthy (2006)
Perfluorooctane-sulfonic Acid (PFOS)		22143	L/Kg	Ahrens et al. (2011)
Perfluorooctane-sulfonic Acid (PFOS)		1069	L/Kg	Ahrens et al. (2011)
Perfluorooctane-sulfonic Acid (PFOS)		5783	L/Kg	Ahrens et al. (2011)
Perfluorooctane-sulfonic Acid (PFOS)		1000	L/Kg	Zareitalabad et al. (2013)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0027, Clay	355	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0029, Till-sand-silt	338	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0031, Till-sand-silt (gravely)	183	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0032, Till-sand-silt	193	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-033, Till-sand-silt	29.3	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0035, Till-sand-silt	6322	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0036, Till-sand-silt	435	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0038, Till-sand-silt (gravely)	166	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0039, Till-sand-silt	1140	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0042, Till-sand-gravel	129	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0043, Silt	727	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0043, Till-sand-gravel	200	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0044, Silt	147	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-044, Clay-gyttja	121	L/Kg	Rosenqvist et al. (2017)

Emerging Pollutant	Description	Koc Value	Units	Source
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0045, Peat-sand-gravel-clay	308	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0048, Silt	87.3	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0048, Till-sand-silt-gravel	232.5	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0050, Clay-sand	73.9	L/Kg	Rosenqvist et al. (2017)
Perfluorooctane-sulfonic Acid (PFOS)	BH-15-0052, Till-sand-silt-gravel	571	L/Kg	Rosenqvist et al. (2017)
PFOS	Minimum	29	L/Kg	
	Median	684	L/Kg	
	Maximum	50,118	L/Kg	
Perfluorooctanioic Acid (PFOA)	Koc	115	L/Kg	ATSDR Profile
Perfluorooctanioic Acid (PFOA)	Koc high	229	L/Kg	ATSDR Profile
Perfluorooctanioic Acid (PFOA)	Koc low	49	L/Kg	ATSDR Profile
Perfluorooctanioic Acid (PFOA)	Koc, high	389	L/Kg	NGWA_PFAS_document
Perfluorooctanioic Acid (PFOA)	Koc, low	83.2	L/Kg	NGWA_PFAS_document
Perfluorooctanioic Acid (PFOA)		223.9	L/Kg	Geosyntec (2019)
Perfluorooctanioic Acid (PFOA)		631.0	L/Kg	Zareitalabad et al. (2013)
Perfluorooctanioic Acid (PFOA)	Sediment	114.8	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	128.8	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Soil	95.5	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Soil	1.1	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Soil	39.8	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	251.2	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Soil	77.6	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Soil	50.1	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Soil	794.3	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Soil	588.8	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Soil	1621.8	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	123.0	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	147.9	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	97.7	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	446.7	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	426.6	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Soil	831.8	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment & Suspended Particulate Matter	1230.3	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment & Suspended Particulate Matter	4168.7	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	--	660.7	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment & Suspended Particulate Matter	79.4	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment & Suspended Particulate Matter	3162.3	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	794.3	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	1000.0	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	2511.9	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	100000.0	L/Kg	ITRC (2022)

Emerging Pollutant	**Description**	**Koc Value**	**Units**	**Source**
Perfluorooctanioic Acid (PFOA)	Sediment	12589.3	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	426.6	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	141.3	L/Kg	ITRC (2022)
Perfluorooctanioic Acid (PFOA)	Sediment	1995.3	L/Kg	ITRC (2022)
PFOA	Minimum	1.1	L/Kg	
	Median	389	L/Kg	
	Maximum	100,000	L/Kg	
Simazine	Sorption Coefficient (soil Koc)	130	L/Kg	OSU Extension Pesticide Properties Database (orst.edu)
Simazine	Sorption Coefficient (soil Koc)	16	L/Kg	Sannino et al (1999)
Simazine	Sorption Coefficient (soil Koc)	400	L/Kg	Beltran et al., (1998)
Simazine	Sorption Coefficient (soil Koc)	833	L/Kg	Beltran et al., (1998)
Simazine	Sorption Coefficient (soil Koc)	58	L/Kg	Reddy et al (1992)
Simazine	Sorption Coefficient (soil Koc)	76	L/Kg	Reddy et al (1992)
Simazine	Sorption Coefficient (soil Koc)	74	L/Kg	Barriuso et al (1997)
Simazine	Sorption Coefficient (soil Koc)	67	L/Kg	Cox et al (1999)
Simazine	Sorption Coefficient (soil Koc)	44	L/Kg	Cox et al (1999)
Simazine	Sorption Coefficient (soil Koc)	445	L/Kg	Cox et al (2000b)
Simazine	Sorption Coefficient (soil Koc)	1700	L/Kg	Cox et al (2000b)
Simazine	Sorption Coefficient (soil Koc)	103	L/Kg	Ahrens (1994)
Simazine	Sorption Coefficient (soil Koc)	152	L/Kg	Ahrens (1994)
Simazine	Sorption Coefficient (soil Koc)	105	L/Kg	Hassink et al (1994)
Simazine	Kurosol - Unifarm	35	L/Kg	Doyle et al (2008)
Simazine	Vertosol - Unifarm	98	L/Kg	Doyle et al (2008)
Simazine	Ferrosol - Huon	74	L/Kg	Doyle et al (2008)
Simazine	Ferrosol - Northdown	74	L/Kg	Doyle et al (2008)
Simazine	Dermosol - Pyengana	95	L/Kg	Doyle et al (2008)
Simazine	Minimum	16	L/Kg	
	Median	95	L/Kg	
	Maximum	1,700	L/Kg	
Sulfometuron methyl	Sorption Coefficient (soil Koc)	78	-	OSU Extension Pesticide Properties Database (orst.edu)
Sulfometuron methyl		85	L/Kg	Tomlin (1994)
Sulfometuron methyl	Fallsington Sandy Loam, pH=5.6	120	L/kg	Montgomery (1997)
Sulfometuron methyl	Flanagan Silt Loam, pH=6.5	122	L/Kg	Montgomery (1997)
Sulfometuron methyl	Myakka Sand, pH=6.3	71	L/kg	Montgomery (1997)
Sulfometuron methyl	Kurosol - Unifarm	89	L/Kg	Doyle et al (2008)
Sulfometuron methyl	Vertosol - Unifarm	66	L/kg	Doyle et al (2008)
Sulfometuron methyl	Vertosol 2 - Unifarm	18	L/Kg	Doyle et al (2008)
Sulfometuron methyl	Ferrosol - Huon	123	L/kg	Doyle et al (2008)
Sulfometuron methyl	Ferrosol - Northdown	76	L/Kg	Doyle et al (2008)
Sulfometuron methyl	Dermosol - Pyengana	160	L/kg	Doyle et al (2008)

Emerging Pollutant	Description	Koc Value	Units	Source
Sulfometuron methyl	Minimum	18	L/Kg	
	Median	85	L/Kg	
	Maximum	160	L/Kg	

Table B.2. Half-Life Values.
Emerging Pollutant Evaluation.

Contaminant	Description	Value	Units	Data Source
2,4-D	soil half life	10	days	OSU Extension Pesticide Properties Database (orst.edu)
2,4-D	soil half life	59.3	days	Meftaul et al (2020)
2,4-D	soil half life	66	days	Walters (undated)
2,4-D	Minimum	10	days	
	Median	59.3	days	
	Maximum	66	days	
2,6-dichlobenzamide (BAM)	degradation is insignificant below the water table	-	-	Degradation of Dichlobenil and BAM
2,6-dichlobenzamide (BAM)	in dichlobenil-contaminated topsoils	two weeks to four months		Degradation of Dichlobenil and BAM
2,6-dichlobenzamide (BAM)	pristine surface soils	5-26 or no degradation	years	Degradation of Dichlobenil and BAM
4-nonylphenol (general)	aerobic microbial degradation, sewage sludge and sediments, low	1.1	days	Occurrence and Biodegradation of Nonylphenol in the Environment
4-nonylphenol (general)	aerobic microbial degradation, sewage sludge and sediments, high	99	days	Occurrence and Biodegradation of Nonylphenol in the Environment
4-nonylphenol (general)	Minimum	1.1	days	
	Median	50.05	days	
	Maximum	99	days	
6PPD quinone	In sediments	337	days	2022_SWTreatmentOfTireContaminants-BMPEffectiveness.pdf (wa.gov)
6PPD quinone	In Soil	75	days	2022_SWTreatmentOfTireContaminants-BMPEffectiveness.pdf (wa.gov)
6PPD quinone	In water	37.5	days	2022_SWTreatmentOfTireContaminants-BMPEffectiveness.pdf (wa.gov)
6PPD quinone	Minimum	37.5	days	
	Median	75	days	
	Maximum	337	days	
AMPA	corn field	71	days	Dynamics of glyphosate and AMPA in the soil surface
AMPA	soybean field	54.7	days	Dynamics of glyphosate and AMPA in the soil surface
AMPA	Sand topsoil, in dark, 20C	60.4	days	Bergstrom et al (2011)
AMPA	Sand subsoil, in dark, 20C	91.3	days	Bergstrom et al (2011)
AMPA	Clay topsoil, in dark, 20C	34.9	days	Bergstrom et al (2011)
AMPA	clay subsoil, in dark, 20C	97.6	days	Bergstrom et al (2011)
AMPA	Minimum	34.9	days	
	Median	65.7	days	
	Maximum	97.6	days	
Atrazine	soil half life	60	days	OSU Extension Pesticide Properties Database (orst.edu)
Bifenthrin	soil half life	26	days	OSU Extension Pesticide Properties Database (orst.edu)
Bifenthrin	Aerobic soil half-life	65	days	Fecko (1999)
Bifenthrin	Aerobic soil half-life	125	days	Fecko (1999)
Bifenthrin	Minimum	26	days	
	Median	65	days	
	Maximum	125	days	
DCOI	soil half life, 2 ug/g soil	4.8	days	Octylisothiazolinone preservatives and industrial biocides
Diuron	soil half life	90	days	OSU Extension Pesticide Properties Database (orst.edu)
Diuron	Aerobic soil, 25 C	372	days	AG (2011)
Diuron	Aerobic soil, 25 C	20	days	AG (2011)
Diuron	Aerobic soil, 20 C	119	days	AG (2011)

Contaminant	Description	Value	Units	Data Source
Diuron	Aerobic soil, 20 C	51	days	AG (2011)
Diuron	Aerobic soil, 10 C	143	days	AG (2011)
Diuron	Aerobic soil, 20 C	27	days	AG (2011)
Diuron	Aerobic soil, 20 C	112	days	AG (2011)
Diuron	Aerobic soil, 20 C	705	days	Madhun and Freed (1987)
Diuron	Aerobic soil, 25 C	653	days	Madhun (1984)
Diuron	Aerobic soil, 25 C	1,378	days	Madhun (1984)
Diuron	Minimum	20	days	
	Median	119	days	
	Maximum	1378	days	
Fipronil	Sandy loam soil, sterile, 15% “water holding capacity”, 20 C	217	days	Ying and Kookana (2002)
Fipronil	Sandy loam soil, sterile, 60% WHC, 20 C	210	days	Ying and Kookana (2002)
Fipronil	Sandy loam soil, non-sterile, 15% WHC, 20 C	198	days	Ying and Kookana (2002)
Fipronil	Sandy loam soil, non-sterile, 30% WHC, 20 C	161	days	Ying and Kookana (2002)
Fipronil	Sandy loam soil, non-sterile, 60% WHC, 20 C	68	days	Ying and Kookana (2002)
Fipronil	Chazay Clay Loam, pH=8.2, WHC=45.3, 20 C	304	days	Fitzmaurice and Mackenzie (2002)
Fipronil	Ongar Clay Loam, pH=7.3, WHC=60.1, 20 C	102	days	Fitzmaurice and Mackenzie (2002)
Fipronil	Royston Clay Loam, pH=8.3, WHC=104.6, 20 C	31	days	Fitzmaurice and Mackenzie (2002)
Fipronil	Levington Sandy Loam, pH=6.6, WHC=39.3, 20 C	221	days	Fitzmaurice and Mackenzie (2002)
Fipronil	Chazay Clay Loam, pH=8.2, WHC=45.3, 10 C	686	days	Fitzmaurice and Mackenzie (2002)
Fipronil	Ongar Clay Loam, pH=7.3, WHC=60.1, 10 C	358	days	Fitzmaurice and Mackenzie (2002)
Fipronil	4 degrees C, 20 % Field capacity moisture	90	days	Mohapatra et al., (2012)
Fipronil	4 degrees C, saturated	61.5	days	Mohapatra et al. (2012)
Fipronil	4 degrees C, saturated	90.13	days	Mohapatra et al. (2012)
Fipronil	Minimum	31	days	
	Median	179.5	days	
	Maximum	686	days	
Glyphosate	aerobic soil metabolism half life, low	1.8	days	Draft Glyphosate Exposure Characterization
Glyphosate	aerobic soil metabolism half life, high	109	days	Draft Glyphosate Exposure Characterization
Glyphosate	Sandy Loam, 25C	1.8	days	EPA (2022)
Glyphosate	Silt Loam, 25C	2.6	days	EPA (2022)
Glyphosate	Sandy Loam, 25C	7.5	days	EPA (2022)
Glyphosate	Sandy Loam, 25C	2.04	days	EPA (2022)
Glyphosate	Sandy Loam, 20C	19.3	days	EPA (2022)
Glyphosate	Scl Loam, 20C	27.4	days	EPA (2022)
Glyphosate	Clay Loam, 20C	7.78	days	EPA (2022)
Glyphosate	Silt Loam, 20C	109	days	EPA (2022)
Glyphosate	Sand topsoil, in dark, 20C	16.9	days	Bergstrom et al (2011)
Glyphosate	Sand subsoil, in dark, 20C	36.5	days	Bergstrom et al (2011)
Glyphosate	Clay topsoil, in dark, 20C	110	days	Bergstrom et al (2011)
Glyphosate	clay subsoil, in dark, 20C	151	days	Bergstrom et al (2011)
Glyphosate	Minimum	1.8	days	
	Median	18.1	days	
	Maximum	151	days	

Contaminant	Description	Value	Units	Data Source
Glyphosate isopropylamine	isopropylamine salt	47	days	OSU Extension Pesticide Properties Database (orst.edu)
Glyphosate isopropylamine	isopropylamine salt, aerobic soil metabolism in sandy loam	1.85	days	EPA Archive
Glyphosate isopropylamine	isopropylamine salt, aerobic soil metabolism in silt loam	2.06	days	EPA Archive
Glyphosate isopropylamine	Minimum	1.85	days	
	Median	2.06	days	
	Maximum	47	days	
Imidacloprid	aerobic	997	days	Environmental Fate of Imidacloprid
MCPA	low	7	days	PubChem
MCPA	high	41	days	PubChem
	Minimum	7	days	
	Median	24	days	
	Maximum	41	days	
Perfluorooctane-sulfonic Acid (PFOS)	-	14965	years	NGWA_PFAS_document, Table 4.3
Perfluorooctanioic Acid (PFOA)	-	33580	years	NGWA_PFAS_document, Table 4.3
Simazine	soil half life	60	days	OSU Extension Pesticide Properties Database (orst.edu)
Sulfometuron methyl	soil half life	20	days	OSU Extension Pesticide Properties Database (orst.edu)