MFS Christie Downs Station

Human Health and Ecological Risk Assessment

South Australian Metropolitan Fire Service

28 November 2024

→ **The Power of Commitment**

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S0	A	Charlotte Gray	Davide Menozzi	** D. Menozzi*	Ben Petticrew	** B. Petticrew*	
S0	B	Charlotte Gray	Davide Menozzi, Kylie Dodd	** D. Menozzi*	Ben Petticrew		28/11/2024

GHD Pty Ltd | ABN 39 008 488 373
Contact: Ben Petticrew, Technical Director - Contaminated Land | GHD
211 Victoria Square, Level 4
Adelaide, South Australia 5000, Australia
T +61 8 8111 6600 | **F** +61 8 8111 6699 | **E** adlmail@ghd.com | **ghd.com**

The Power of Commitment

Executive Summary

South Australian (SA) Metropolitan Fire Service (MFS) commissioned GHD Pty Ltd (GHD) to undertake a human health and ecological risk assessment (HHERA) for the per- and polyfluoroalkyl substances (PFAS) impacts associated with the historical use of aqueous film forming foam (AFFF) at the MFS Christie Downs Fire Station (hereafter referred to as 'the site'). The site is located at 3 Holman Road, Christie Downs, South Australia 5086.

The station has been closed and non-operational since December 2022. It is understood that MFS intends to divest the site. The site is currently zoned for Housing Diversity Neighbourhood, which allows for a range of potential land uses, including medium-density housing and associated non-residential land uses, such as shops, childcare and recreational facilities, but the future land use for the site is unknown.

Stormwater flow is the main pathway via which PFAS impacts migrate from the site, with surface water and rainwater runoff entering the stormwater system and discharging into Christie Creek, located approximately 530 m northwest and uphill from the site.

This Report provides a HHERA for PFAS identified in the following areas (shown in Figures 1 and 2 in Appendix A):

– **Zone 1** – The site.
– **Zone 2** – Holman Rd, adjacent to the site, the unsealed utilities corridor, and the reserve area east of Holman Rd.
– **Zone 3** – The receiving environment of Christie Creek.

These three zones collectively are referred to as 'the Investigation Area'. The HHERA estimates the potential risk to human health and the environment associated with PFAS impacts identified within the Investigation Area.

Objectives of the HHERA

The overarching purpose of the works undertaken by GHD is to assist MFS in managing the identified PFAS impacts in the context of the site's proposed divestment and redevelopment and the relevant adjacent land uses and receiving environments.

Specifically, the primary objective of this HHERA is to assess the potential risks to human health and the environment that may be associated with PFAS contamination within the Investigation Area under the land use patterns that are possible for the onsite area in the future, including the following:

– Scenario 1 – The site is developed for low-density residential use.
– Scenario 2 – The site is developed for medium-to-high-density residential use.
– Scenario 3 – The site is developed for commercial/industrial.
– Scenario 4 – The site is developed as a childcare facility.
– Scenario 5 – The site is developed as an open space area with recreational use.

It is noted that there is no expectation that the land use in the offsite areas of the Investigation Area (including Zones 2 and 3) will change in association with the future onsite redevelopment.

Outcomes for Zone 1 (Former MFS site)

The key outcomes of the HHERA undertaken for Zone 1 can be summarised as follows:

– The consumption of even a relatively small amount of produce grown within Zone 1 could be associated with intakes of PFOS+PFHxS above the tolerable daily levels defined by Australian health and environmental regulators.
– There is a low risk that the intake of PFOS+PFHxS by future site users will exceed the tolerable daily levels defined by Australian health and environmental regulators if the site is redeveloped in such a way that direct contact with soil is limited.

- Examples of developments that would minimise direct contact with soil include medium-to-high-density residential developments or commercial developments, where most of the site is covered with buildings and paving.
- These outcomes reflect the limited volatility of PFOS+PFHxS and that exposure to PFAS in soil primarily occurs in association with the incidental ingestion of soil (e.g. hand-to-mouth actions) and the bioaccumulation of PFAS in homegrown food.
- On-site soil sampling was limited to accessible areas and did not include areas covered by buildings, which account for approximately 30% of the Zone 1 area. Additional onsite soil investigations will be required following building demolition to inform the development and remediation planning process.
- While the future use of Zone 1 had not been established at the time of reporting, human use will be the primary purpose rather than ecological values.

Outcomes for Zone 2 (Roadway, Utilities Corridor and Reserve)

The HHERA undertaken for Zone 2, demonstrated that exposure to PFAS-contaminated soil in Zone 2 is limited and represents a low risk to people and ecological receptors accessing the area.

The planning for the management of the PFAS-impacted soils in Zone 2 should focus on other factors, including stakeholder perceptions around the presence of elevated PFAS levels in publicly accessible land, the role of this area as an ongoing source of PFAS to the surrounding environment and the requirement for PFAS-impacted soil to be managed appropriately during future intrusive work.

Outcomes for Zone 3 (Christie Creek)

The key outcomes of the HHERA was undertaken for Zone 3 can be summarised as follows:

- The levels of PFAS in Christie Creek pose low risks to human users of the area.
- Direct exposure to PFAS represents a low risk to aquatic organisms inhabiting the creek.
- A clear indication of a measurable impact of the site on PFAS concentrations in Christie Creek surface water is not apparent in the dataset collected to date.
- Some bioaccumulation of PFAS likely occurs in lower trophic level organisms inhabiting Christie Creek, both upstream and downstream of the site. The weight of available evidence does not suggest that there are likely to be measurable adverse effects on higher trophic-level organisms.
- Future development works that reduce the areas of exposed surface soil in Zone 1 and Zone 2 will also reduce the migration of PFAS via stormwater runoff.

Several data gaps and uncertainties associated with the HHERA have been identified and are summarised in Section 3.3.2 and Section 4.4.

This Report is subject to and must be read in conjunction with, the limitations set out in Section 1.6 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

This Report provides a human health and ecological risk assessment (HHERA) for the per- and polyfluoroalkyl substances (PFAS) impact associated with the historical use of aqueous film forming foam (AFFF) at the South Australian Metropolitan Fire Service (MFS) Christie Downs Fire Station (hereafter referred to as 'the site').

The site is located at 3 Holman Road, Christie Downs, South Australia 5164. A site location plan is presented in Figure 1 in Appendix A. The station has been closed and non-operational since December 2022. It is understood that MFS intends to divest the site. The site is currently zoned for Housing Diversity Neighbourhood, allowing for a range of potential land uses, including medium density housing and associated non-residential land uses (e.g., shops, childcare, and recreational facilities). However, the specific future land use for the site has not been confirmed. The site is approximately 24 kilometres south-west of the Adelaide central business district.

1.1 Background

MFS commissioned GHD Pty Ltd (GHD) to investigate the nature and extent of PFAS at the site. The results of the PFAS investigations undertaken within and surrounding the site are presented in the following two reports:

- GHD (2023a) *MFS Christie Downs Station - Detailed Site Investigation* – dated 29 November 2023 (also referred to as “the DSI”).
- GHD (2024) *MFS Christie Downs Station - Supplementary Detailed Site Investigation* – in preparation (also referred to as “the supplementary DSI”).

These investigations included collecting soil samples from the site and adjacent areas to the east.

Stormwater flow is the main pathway via which PFAS impacts migrate from the site and the adjacent area to the east, with surface water and rainwater runoff generated in these areas entering the stormwater system and discharging into Christie Creek, located approximately 530 m northwest and uphill from the site. Surface water and sediment samples were also collected from Christie Creek during the DSI and Supplementary DSI. Christie Creek is hereafter referred to as “the receiving environment”.

This Report provides a HHERA for the PFAS identified in the following key zones (identified in Figures 1 and 2 in Appendix A):

- **Zone 1** – The site.
- **Zone 2** – Holman Rd, adjacent to the site, the unsealed utilities corridor and the reserve area east of Holman Rd.
- **Zone 3** – The receiving environment of Christie Creek.

These three zones are collectively referred to as 'the Investigation Area'. The HHERA estimates the potential risk to human health and the environment associated with PFAS impacts identified within the Investigation Area.

This Report is subject to and must be read in conjunction with the limitations set out in Section 1.6 and the assumptions and qualifications contained throughout the Report.

1.2 Objectives of the HHERA

The overarching purpose of the works undertaken by GHD is to assist MFS in managing the identified PFAS impacts in the context of the site's proposed divestment and redevelopment and the relevant adjacent land uses and receiving environments.

Specifically, the primary objective of this HHERA is to assess the potential risks to human health and the environment that may be associated with PFAS contamination within the Investigation Area under the land use patterns that are possible for the onsite area in the future, including the following:

- Scenario 1 – The site is developed for low-density residential use.
- Scenario 2 – The site is developed for medium-to-high-density residential use.
- Scenario 3 – The site is developed for commercial/industrial
- Scenario 4 – The site is developed as a childcare facility
- Scenario 5 – The site is developed as an open space with recreational use.

It is noted that there is no expectation that the land use in the offsite areas of the Investigation Area (including Holman Road, the unsealed reserve to the east and the receiving environment of Christie Creek) will change in association with the future onsite redevelopment.

1.3 Risk Assessment framework and methodology

The HHERA has been prepared with reference to the following legislation and guidance:

- National Environmental Protection Council (NEPC, 1999) *National Environment Protection (Assessment of Site Contamination) Amendment Measure* 1999, as amended 2013 (the "ASC NEPM"):
- EnHealth (2012a) *Australian exposure factor guidance*.
- EnHealth (2012b) Environmental health risk assessment: guidelines for assessing human health risks from environmental hazards.
- Australian and New Zealand Governments (ANZG, 2018) *Australia and New Zealand Fresh Water and Marine Water Quality Guidelines*.
- Heads of EPAs Australia and New Zealand (HEPA, 2020) *PFAS National Environmental Management Plan, version 2.0 (the "PFAS NEMP")*.
- National Health and Medical Research Council (NHMRC, 2019), *Guidance on Per and Polyfluoroalkyl substances (PFAS) in Recreational Water.*
- National Health and Medical Research Council / Natural Resource Management Ministerial Council (NHMRC/NRMMC, 2011) *Australian Drinking Water Guidelines,* updated September 2022 ('the ADWG').
- Food Standards Australia New Zealand (FSANZ, 2017) *Report on Perfluorinated Chemicals in Food*.
- SA EPA (2019) *Guidelines for the assessment and remediation (GAR) of site contamination, Environment Protection Authority, South Australia*, revised November 2019.
- SA Government (2015) *Environment Protection (Water Quality) Policy (WQEPP)*, version 1.7.2020.

Guidance provided by international agencies has been referenced where required and consistent with these guidelines and legislation.

HEPA (2022) has also released the draft for public consultation of the PFAS NEMP (3.0). Although this document had not been finalised at the time of reporting, the guidance provided has also been referenced in this HHERA where relevant.

ANZG (2023) also released a draft of revised water quality guidelines (WQG) for PFOS in freshwater systems, and the Department of Climate Change, Energy, the Environment and Water (Dawson, Le-Steere, Mann, Stauber, & Vardy, 2024) recently released an official independent review of these values. These documents have also been referenced in this HHERA where appropriate.

Human health and ecological risk assessments in Australia primarily follow the methodologies outlined in the ASC NEPM (NEPC, 1999). Fundamental to the HHERA process is the development of a Conceptual Site Model (CSM), which is a description of the plausible mechanisms ('pathways') by which people and ecosystems ('receptors') may be exposed to chemicals in the environment ('sources'). Potential risks to human health and the environment cannot occur unless there is a complete exposure pathway associated with a source of contamination. Conversely, complete exposure pathways do not, by default, indicate a receptor will be at risk; the risk assessment process is used to evaluate the extent of the potential risks.

The key steps in the ASC NEPM HHERA process are outlined in Plate 1.1 overleaf and can be summarised as follows:

– ***Problem identification:*** establishes the objectives of the HHERA, evaluates the available data and establishes a preliminary CSM.
– ***Receptor identification*****:** identifies the human and ecological species that may be at risk and evaluates the level of acceptable risk in the context of the ecological values that need to be protected.
– ***Toxicity* assessment:** establishes the relationships between PFAS exposure and potential health and ecological effects, using published toxicological information.
– ***Exposure assessment:*** produces estimates of the PFAS exposure that may be experienced by the identified human and ecological receptors of the Investigation Area and within the Investigation Area.
– ***Risk characterisation:*** combines the results of the toxicity assessment and exposure assessment to provide numerical estimates of the potential health and ecological risks to relevant receptors.
– ***Uncertainty and sensitivity assessment:*** evaluates the uncertainty associated with the HHERA and sensitivity of the assessment outcomes to the various assumptions and inputs.

The issues identification process for this HHERA is outlined in Section 3, and the human health risk assessment (HHRA) and ecological risk assessment (ERA) are presented in Section 4 and Section 5, respectively.

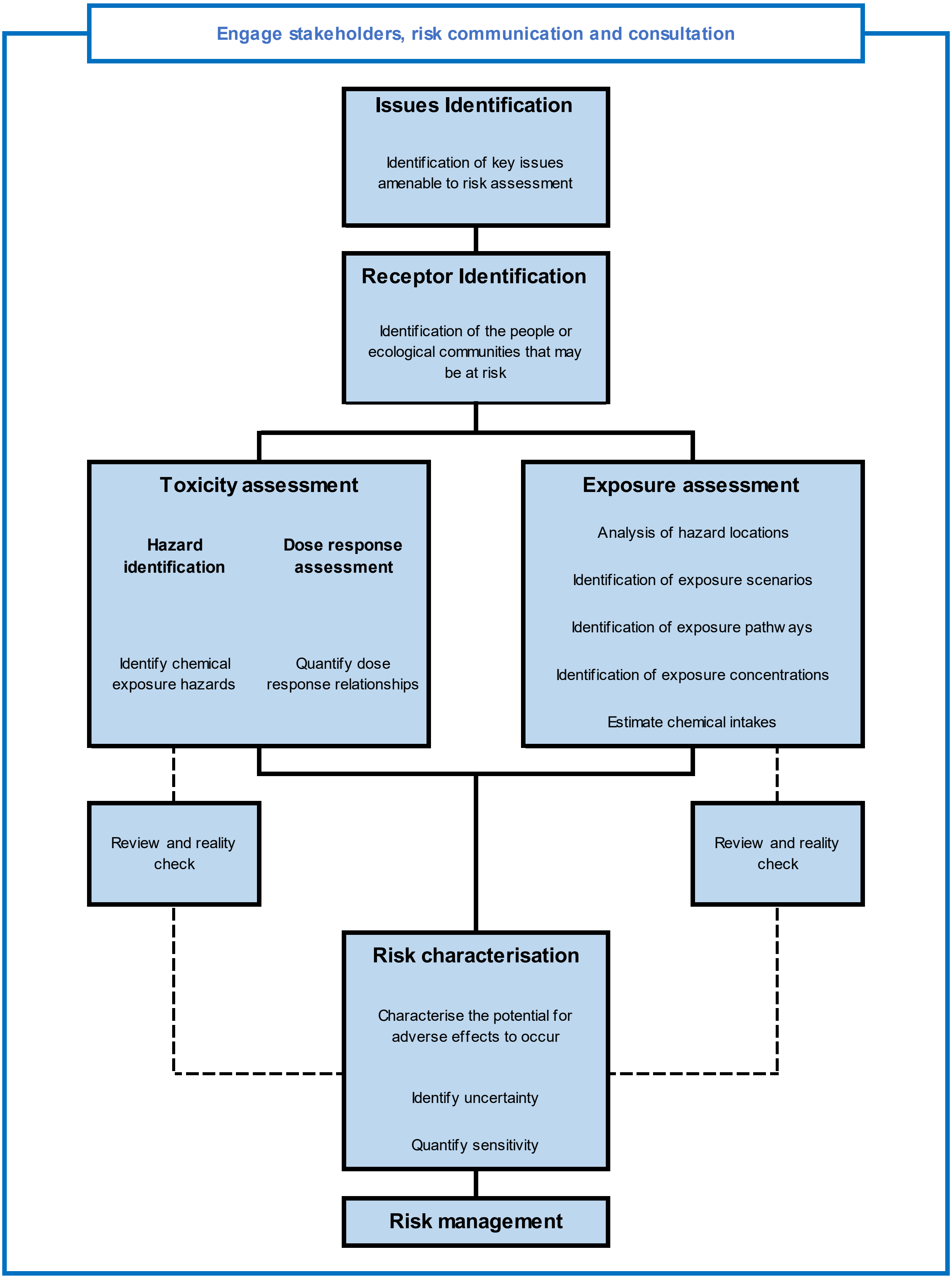

Plate 1.1 ***HHERA methodology (enHealth, 2012a; NEPC, 1999)***

1.4 Overview of PFAS

PFAS is a large family of manufactured chemicals used in Australia and worldwide in various commercial processes, household products, and specialty applications. The physical and chemical properties of PFAS impart oil and water repellence, temperature resistance and friction reduction, making them useful to consumers and industry.

Firefighting foams containing perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) as active ingredients were once used extensively worldwide and within Australia, including at fire stations and fire training facilities. Perfluorohexane sulfonate (PFHxS) was also commonly found in firefighting foam as an impurity of its manufacturing process.

Scientists have identified many individual PFAS compounds, but the individual PFAS that generally account for the majority of the PFAS mass in environmental samples include the following:

– Perfluoroalkyl sulfonates (PFSA), of which PFOS and PFHxS are the most well-studied.
– Perfluoroalkyl carboxylates (PFCA), of which PFOA is the most well-studied.
– Fluorotelomers (FtS), including 8:2 FtS and 6:2 FtS.
– Perfluoroalkyl sulfonamides.

The guidelines produced by Australian environmental regulators, as detailed in Section 1.3, have focused on PFOS, PFHxS, and PFOA, with PFOS and PFHxS being the predominant PFAS identified within the site and the Investigation Area. PFOS and PFHxS, as well as PFOA, are therefore the focus of this HHERA. The other PFAS detected at relatively lower concentrations within the Investigation Area have been evaluated in Sections 4.4 and 5.3.

1.5 Data Sources

This HHERA draws primarily upon the dataset collected from within the Investigation Area by GHD (2023a; 2024) and other publicly available data. A consolidated dataset is presented in Appendix B.

1.6 Limitations

This Report has been prepared by GHD for the South Australian Metropolitan Fire Service and may only be used and relied on by the South Australian Metropolitan Fire Service for the purpose agreed between GHD and South Australian Metropolitan Fire Service as set out in Section 1.2 of this Report.

GHD otherwise disclaims responsibility to any person other than the South Australian Metropolitan Fire Service arising in connection with this report. GHD also excludes implied warranties and conditions to the extent legally permissible.

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in the Report and are subject to the scope limitations set out in the Report.

The opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD described in this report (refer Section(s) 1.7 of this Report). GHD disclaims liability arising from any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this Report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this Report.

GHD has prepared a human health and ecological receptors exposure model ("Model") for, and for the benefit and sole use of, South Australian Metropolitan Fire Service to support the assessment of human health and ecological risks at the site and within the Investigation Area and must not be used for any other purpose or by any other person.

The Model is a representation only and does not reflect reality in every aspect. The Model contains simplified assumptions to derive a modelled outcome. The actual variables will inevitably be different to those used to prepare the Model. Accordingly, the outputs of the Model cannot be relied upon to represent actual conditions without due consideration of the inherent and expected inaccuracies. Such considerations are beyond GHD's scope.

The information, data and assumptions ("Inputs") used as inputs into the Model are from publicly available sources or provided by or on behalf of the South Australian Metropolitan Fire Service (including possibly through stakeholder engagements). GHD has not independently verified or checked Inputs beyond its agreed scope of work. GHD's scope of work does not include review or update of the Model as further Inputs becomes available.

The Model is limited by the mathematical rules and assumptions that are set out in the Report or included in the Model and by the software environment in which the Model is developed.

The Model is a customised model and not intended to be amended in any form or extracted to other software for amending. Any change made to the Model, other than by GHD, is undertaken on the express understanding that GHD is not responsible, and has no liability for the changed Model including any outputs.

1.7 Assumptions, inclusions and exclusions

This Report has been prepared with reference to the guidance presented in Section 1.3 and incorporates the following key considerations:

- This HHERA is limited to assessing the risks to human health and the environment associated with exposure to PFAS in soil, surface water and sediment within the Investigation Area. Other potential contaminants, exposure media and areas have not been considered.
- The term PFAS refers to a large number of perfluorinated and polyfluorinated substances. The analytical suite adopted for this assessment incorporated 28 compounds, including PFOS, PFHxS and PFOA, which are the primary focus of this Report.
- The toxicity endpoints used in this HHERA were consistent with the guidance Australian health and environmental regulators provided at the time of reporting.
- The findings presented within this Report are primarily based on the field and analytical results referenced in Section 1.5. The potential for health and ecological risks is assessed based on the conditions at the time of sampling and in the areas sampled.

2. Investigation Area setting

A detailed description of the Investigation Area is presented in the DSI and supplementary DSI reports (GHD, 2023a; 2024). A summary of this information is provided herein.

2.1 Investigation Area identification

Site identification information for the MFS Christie Downs Fire Station (Zone 1) is summarised in Table 2.1. A site location plan showing key site features is presented in Figure 1 in Appendix A.

Table 2.1 Summary of site identification information

Item	Detail
Site address:	3 Holman Road, Christie Downs, South Australia
Certificate of Title:	CT 5534/85 and CT 5534/90
Legal description (Parcel ID)[a]	Allotments 120 and 121 in Deposited Plan 10165 in the area named Christie Downs, Hundred of Noarlunga
Local government authority:	City of Onkaparinga
Current zoning:	Housing Diversity Neighbourhood
Property Owner:	South Australian Metropolitan Fire Service
Current site use:	Non-operational fire station
Proposed future land use	Unknown but may include low, medium or high-density residential or commercial.
Area:	2,255 m^2
Site elevation:	64-70 m Australian Height Datum (AHD)
[a] Based on cadastral data provided by the Government of South Australia Location SA Map Viewer	

Housing Diversity Neighbourhood Zones have a desired outcome: "*medium density housing supports a range of needs and lifestyles, located within easy reach of a diversity of services and facilities*" (Plan SA, 2024). The following key development types are included in the deem-to-satisfy criteria (but not limited to):

- Childcare, community or educational facilities
- Dwelling
- Dwelling of residential flat building undertaken by:
  - The South Australian Housing Trust, either individually or jointly with other persons or bodies
  - A provider registered under the Community Housing National Law participating in a program relating to the renewal of housing endorsed by the South Australian Housing Trust.
- Row dwelling
- Semi-detached dwelling
- Recreational area
- Retirement facility
- Shop

Site identification information for the offsite Zones 2 and 3 are summarised in Table 2.2.

Table 2.2 Summary of land use within the Investigation Area

Zone	Details	Legal description (Parcel ID)[a]	Zoning	Current land use	Proposed future land use
2	Adjacent Holman Road, carpark, and unsealed utilities corridor and reserve area.	Part of D9667 A348	Suburban Activity Centre	Road, carpark, utilities corridor and reserve.	Unchanged
3	Christie Creek (within Investigation Area)	Across multiple lots, including but not limited to: D9826 A41 D12136 A123 D10171 A293 D10170 A292 D9768 A78 D9768 A79 D9768 A80	General Neighbourhood, Housing Diversity Neighbourhood and Strategic Employment[b]	Creek and public reserve	Unchanged

[a] Based on cadastral data provided by the Government of South Australia Location SA Map Viewer
[b] Some of the key zoning of the multiple lots

2.2 Investigation Area description

A description of the Investigation Area is provided herein. Additional details are provided in Appendix F.

2.2.1 MFS site (Zone 1)

The site was not in use at the time of Reporting, but it was used as an operational fire station until December 2022. The onsite infrastructure consists of the following (refer to Figure 2 in Appendix A):

- The former main office building and attached engine bay are in the site's centre.
- A former gym and storage shed along the north-west boundary.
- A shed adjoining the north-east corner of the main office building
- A driveway along the southern and western site boundary.
- Unsealed (gravelled and grassed) area within the station fence in the northeast corner.
- Grassed, unsealed area in the north-east corner outside the station fence and north of the driveway.
- One mature tree (unknown species) is on the site's western perimeter.
- Fruit trees (lime and apricot) were present along the site's southern boundary and were removed prior to the station's closure. The data has been included in Section 3.2.3 for completeness.

Photographs from the site are shown below in Table 2.3.

Table 2.3 Site photographs

	
Photograph A: North-eastern corner of the fire station, facing south-west (prior to closure). Grassed area outside of the fence.	**Photograph B: Southern boundary of the site, facing west (prior to closure). Drain running along the front of the building and fire hydrant on the boundary.**
	
Photograph C: South-eastern corner of the site, facing south-west (post closure). Driveway and drain located to the east of the building.	**Photograph D: Southern boundary of the site, facing east (post closure). Driveway located along the southern boundary with drains and fruit trees, which have since been removed.**
	
Photograph E: North-eastern corner of the site, facing north-west (post closure).	**Photograph E: Rear of the site, facing south (post closure).**

2.2.2 Offsite – Holman Rd and reserve area (Zone 2)

East of the site is Holman Road and an unsealed utilities corridor and reserve area that can be described as follows:

– The area between the site and Midhurst Ave, including a section of Holman Rd and carparks, with the following approximate dimensions:
  - Width 30 to 45 m
  - Length 95 m
– Holman Road slopes southerly towards Flaxmill Road. It is connected to Midhurst Avenue to the east but not directly to Radcliffe Grove to the north.
– The reserve area is primarily a utilities corridor with overhead power lines and underground water and wastewater mains. It also appears to be used by pedestrian traffic from the northern residential area to the shopping centre located to the east and Flaxmill Road, where bus stops are located. Notably, a large park is located south of Flaxmill Road (Nipu-nipu Wama/Morton Park), which includes an oval, playground, skate park, and public amenities.
– The reserve area is mainly grassed with a few mulched areas: one sealed concrete pedestrian track and two unsealed tracks. It is sparsely vegetated with some mature trees.

Photographs of the area are shown below in Table 2.4.

Table 2.4 Zone 2 photographs

	
Photograph A: Driveway and Holman Rd to the east of fire station, facing east.	***Photograph B: Driveway and Holman Rd to the east of fire station, facing south-east.***
	
Photograph C: Grassed nature strip, Holman Rd and adjacent reserve to the east of the fire station. Predominantly grass species and weeds, with some mature trees.	**Photograph D: Drain located down gradient of the site along Holman Rd, before Flaxmill Rd.**

2.2.3 Christie Creek (Zone 3)

The nearest natural surface water body to the site is Christie Creek, located approximately 530 m northwest and uphill from the site.

Most of the stormwater from Zone 1 and Zone 2 discharges to offsite underground stormwater drains via stormwater drainage pipes, as follows:

– Stormwater from the site is captured in drains to the east (i.e., front of the site) of the engine bay and along the southern site boundary.
– The drains and surface water runoff from Holman Road in front of the station discharges to the south of the site and into the public stormwater system on Flaxmill Road.
– The public stormwater system follows Flaxmill Road and Copernicus Rd (as shown in Figure 5, Appendix A) and discharges into Christie Creek north of the intersections of Gerald Ct and Joan Ct near-surface water sampling location SW03 (Government of South Australia, 2024).

Christie Creek originates in the Onkaparinga Hills, approximately 5 km west of the site, and flows in a westerly direction through the residential areas of Morphett Vale, Christie Downs, Christie Beach and O’Sullivan Beach and the commercial/industrial area of Lonsdale. This waterway discharges into the Gulf of St Vincent at Christie Beach, approximately 2.5 km west of the site.

Multiple stormwater outlets discharge to Christie Creek along its flow path. Downstream of the discharge outlet from the site are stormwater outlets that discharge stormwater from residential areas and the Lonsdale commercial/industrial area. There also appear to be multiple stormwater retention ponds adjacent to the creek, including one located west of the site adjacent to Tomorrow Rd, Christie Creek. There are numerous Section 83A notified sites within the catchment area of Christie Creek that may contribute to ambient PFAS levels in this water system, including:

– Oil refineries, notably the former Adelaide Refinery at Port Stanvac
– Metal processing, smelting, refining or metallurgical works located at 70 Barden Terrace, O'Sullivan Beach, SA
– Numerous service stations located in Morphett Vale and Christies Beach

Within the commercial/industrial area at Lonsdale, aerial imagery shows evidence of car wrecking and earthwork activities at 108 O'Sullivan Beach Road and subdivisions between Dyson Rd and Donegal Rd. Both of these sites are adjacent and upgradient to Christie Creek.

Upstream of the point of stormwater discharge from the site, the Christie Creek riparian area of endangered Grey Box Grassy Woodland (City of Onkaparinga, 2024). Christie Creek was a project site within the City of Onkaparinga Urban Creek Recovery Project. This Project included the monitoring of vegetation, bush regeneration, woody weed control, revegetation and rubbish removal.

The base flow of Christie Creek was calculated in 2005 to be greater than 100 L/ha/day (Wlkinson, Hutson, Bestland, & Fallowfield, 2005) with an estimated discharge of approximately 8 GL annually, which was noted to be unusually high compared to other urbanised creeks in this area.

The general characteristics of Christie Creek can be summarised as follows:

– Christie Creek ranges from approximately 1 to 5 meters in width and 0.6 meters in depth outside periods of high flow.
– The riparian zone varies in gradient from gentle to steep and is largely vegetated, with grasses, reeds and native tree species (particularly eucalyptus) and weed species.
– Two road bridges (Southern Expressway and Dyson Road) and one railway lie across Christie Creek within the Investigation Area. There is a concrete creek bed and embankment beneath Dyson Rd and a large culvert allowing the creek to flow beneath the railway embankment.
– A steel pipe intersects the creek surface near SW10, allowing water to flow underneath but capturing larger rocks and floating detritus.
– Near SW11, there is some erosion from the steep embankment and a fallen tree across the creek.
– The creek bed comprises various natural substrates, including large rocks, pebbles, sands, silts, and detritus.
– Rock gabions form the creek bed and embankment at SW12 and SW13, likely to mitigate erosions, which can be seen downstream of the gabions.
– Stormwater collected across the surrounding urban areas discharges into Christie Creek at various locations, including at least 16 locations downstream of the SW03.

Photographs of the area are shown below in Table 2.5.

Table 2.5 Zone 3 photographs – dry conditions were observed on 12 March 2024, while wet conditions on 11 July 2024

	
Photograph A: Christie Creek, approximately 1.5 km north-east and upstream of the fire station, near location SW07. Gentle sloped bank with grass and reeds. Dry weather conditions.	**Photograph B: Christie Creek near SW05/SW08, approximately 500 m north of the fire station, upstream of stormwater discharge from fire station. Dry weather conditions.**
	
Photograph C: Christie Creek near SW05/SW08. Some bank erosion. Wet weather conditions.	**Photograph D: Christie Creek near SW04/SW09. Overhanging vegetation and trees in the water. Wet weather conditions.**
	
Photograph E: Christie Creek near SW04/SW09, approximately 600 m north-west of the fire stationDry weather conditions.	**Photograph F: Stormwater drain discharging into Christie Creek, 750 m north-west of the fire station, near SW03. Potential drain where stormwater from site would discharge. Dry weather conditions.**

Photograph G: Another stormwater drain discharging into Christie Creek (adjacent to Photograph F), 750 m north-west of the fire station, near SW03. Potential drain where stormwater from site would discharge. Dry weather conditions.

Photograph H: Christie Creek near SW01/SW11 and east of Dyson Rd, showing concrete bank and some erosion. Dry weather conditions.

Photograph I: Christie Creek near SW01/SW11. Showing fast flowing conditions during wet weather.

Photograph J: Christie Creek near SW12 showing rock gabions, stepped structure and some bank erosion.

	
Photograph K: Christie Creek near SW12. Wet weather conditions.	**Photograph L: Christie Creek near SW13 showing rock gabions, some bank erosion, grasses and weeds.**
	
Photograph M: Christie Creek near SW13. Wet weather conditions.	**Photograph N: Christie Creek near SW14 facing west towards beach. Showing some erosion, runs and pools. Wet weather conditions.**

2.3 Environmental setting

The environmental setting of the Investigation Area is summarised in Table 2.6.

Table 2.6 Investigation Area environmental setting summary

Element	Summary
Surrounding land use	The Investigation Area is surrounded by the following land uses: – East – Retail (Flaxmill Rd shopping centre) – South – Commercial (Telstra Exchange), major road (Flaxmill Rd), community centre and recreational areas (including Morton Park oval and skate park, and Peregrine Park). – West – Medium-density residential, grassed reserve and Christie Downs railway corridor – North – Radcliffe Grove and low and medium-density residential Given the location of the site near the shopping centre, major road and train station, future land use is more likely to be medium-density residential or commercial rather than low-density residential properties with large gardens. According to the census data, the average household size in the area is 2.2 people (ABS, 2024).
Topography	The general topography of the area is relatively flat and forms part of the Adelaide Plains, between the Gulf of St Vincent to the west and the Mount Lofty Ranges to the east. The site slopes gradually upwards to the northern boundary at an elevation of 64 m AHD. Most of the property is sealed with narrow garden beds running along the north and southern boundary and a garden bed and gravelled area in the site's northeast corner.
Geology	GHD (2023a) indicates the geology underlying the Investigation Area is Hindmarsh Clay, Carisbrooke Sand, Ochre Cove Formation and Seaford Formation, consisting of calcareous loam on clay. However, the geology encountered in the Investigation Area during intrusive works was inconsistent with the regional geology and is more consistent with the Wilmington Formation. The lithology can generally be summarised as follows: – 0 - 0.4 m bgl – Silty sands, fill. – 0.4 – 2.8 m bgl – Clayey sands, natural. – 1.1 – 3.5 m bgl – Clay, low plasticity, natural. – 2.5 – 10 m bgl – Siltstone, pale brown – 10 – 11.2 m bgl – Silty clay, dark brown (possibly highly weathered siltstone)[1] – 11.2 – 20 m bgl – Siltstone, pale brown
Regional hydrogeology	The hydrological characteristics of the Investigations Area lie within the 'hydrogeological zone 1', which covers the basement rocks of the Adelaide Hills and contains a fractured rock aquifer (Gerges, 2006). The expected groundwater aquifer underlain the site comprises sedimentary rocks, including limestone (cavernous), sandstone, sand shale, and clay material. A second aquifer unit was identified at 484 m north-west of the site. It was described as fractured rocks – Cambrian and Precambrian rocks – quartzite, sandstone, limestone, dolomite, slate, marble, siltstone, phyllite, schist and gneiss (Gerges 2006). A search of the South Australian Resources Information Gateway (SARIG) database reported the site is within an area of shallow groundwater with standing water levels (SWL) of 10 - 20 m AHD, producing yields of 0.5 - 2.5 L per second. Groundwater salinity ranged from approximately 3,000 - 7,000 mg/L total dissolved solids (TDS), indicating brackish water. TDS data was available for 18 wells within the 2 km radius of the site and ranged between 80 mg/L and 10,939 mg/L. The 80 mg/L data point is likely an error when considering the wider regional aquifer properties; therefore, the TDS data indicates the likely regional presence of brackish groundwater. Site-specific hydrogeological information is provided in Section 0
Climate	Adelaide has dry and warm summers with low rainfall. The annual rainfall at Adelaide Morphett Vale (Bureau of Meteorology weather station no. 23732), which reports data since 1886, totals 570.5 mm. Typically, the wettest month occurs in June, with an average of 76.1 mm of rainfall, while February is typically the driest, receiving only 21.4 mm of rainfall on average.

[1] As the deep borehole was advanced using air hammer, there is limited geological information of fracturing and weathering profiles in the rock.

2.3.1 Local hydrogeology

The SARIG database identifies 12 wells registered within 1 km of the site (discussed further in Section 2.4.2). Of the 12 wells, only one was associated with a recorded standing water level (SWL). This well was installed in 1950 to a total depth of 18.9 m below ground level (m bgl), with a final SWL of 7.62 m bgl, suggesting groundwater may be shallower than 20 m bgl.

In 2023, GHD (2023a) drilled a borehole onsite to a depth of 20 m bgl using an air hammer. No water was identified during drilling, so the borehole was filled back to 10.8 m bgl. A groundwater well (MW01) was installed at this depth, targeting a slightly moist layer of silty clay between 10 and 11.3 m bgl. However, since the well was installed, no water has been observed in the well.

As regional groundwater is likely located within a fractured rock aquifer and air hammering does not allow for fracturing to be observed, there is a possibility that the borehole did not intersect a water-bearing fracture. Only one well onsite also means there remains some uncertainty regarding groundwater depth within the Investigation Area.

The groundwater flow direction is unconfirmed. However, given that the coast is located to the west and the closest stream is located to the north, it is likely that the regional groundwater flow direction ranges between north and west. It is unlikely that regional groundwater flows towards the east, towards an area of higher surface elevation and away from the coast.

2.3.2 Hydrology of the Investigation Area

The drainage system of the Investigation Area is shown in Figure 1 (Appendix A) and can be summarised as follows:

Onsite:

– Buildings and concrete hardstand areas cover approximately half of the site. Stormwater runoff from these areas is collected via onsite drains, most flowing into underground stormwater drains offsite.
– The drains receiving stormwater from the site are located along the southern site boundary. These drains flow into the council stormwater system on Holman Rd east of the site.
– The site's northeast corner is gravel, and some vertical infiltration may occur during heavy rainfall.
– Historically, after exercises or incidents involving AFFF usage, equipment and tanks were washed down on the driveway in front of the fire station.

Offsite:

– Historic washdown activities in front of the fire station potentially overflowed onto Holman Road.
– Runoff from Holman Rd and most of the reserve area appears to drain south towards the stormwater drain at the end of the carpark on Holman Rd near Flaxmill Road.
– Runoff from a small portion of the western side of the reserve may drain to the east to Midhurst Ave and collect in the stormwater drain on Midhurst Ave, which connects to the council stormwater system on Flaxmill Road.
– The offsite council stormwater system runs beneath Flaxmill Road, continues beneath Copernicus Rd to the west and ultimately discharges into Christie Creek.
– Multiple stormwater points discharge into Christie Creek, including 17 other stormwater outlets downstream of the discharge from the site.

2.4 Human use of the Investigation Area

2.4.1 Land use

The site (Zone 1) and Holman Road (Zone 2) are zoned as Housing Diversity Neighbourhood by PlanSA. The site was previously used as an operational fire station, but it is proposed to be redeveloped. As described in Section 2.1, the Housing Diversity Neighbourhood zoning allows for these key development types that have been considered as part of the human health risk assessment:

- Low-density residential – Dwelling
- Medium-density residential – Demi-detached dwelling and row dwelling
- High-density residential – Dwelling of residential flat building, retirement facility
- Commercial/industrial – Shop
- Childcare facilities
- Recreational – Open space, recreational area

The eastern half of the Reserve Area (Zone 2) is zoned as Suburban Activity Centre with the adjacent shopping centre to the east.

Christie Creek (Zone 3) mostly runs along the boundaries of the Housing Diversity neighbourhood to the south and the Strategic Employment area to the north. Most of the area is accessible to the public for recreational purposes. A walking and cycling trail network called the Christie Creek Linear Trail runs along the Creek.

2.4.2 Groundwater use

A reticulated water supply serves the site and its surrounding areas.

GHD searched for registered groundwater wells within a ~2 km radius of the site using the SA WaterConnect Database in July 2024 (see Figure 3 in Appendix A). Results can be summarised as follows:

– 121 active registered wells were identified, with 17 listed as backfilled, dry, abandoned, or unused.
– Two bores were registered for irrigation and 81 for investigation/monitoring/environmental purposes. No purpose was recorded for 38 registered wells.
– Where reported, total dissolved solids (TDS) ranged from 80 to 10,939 mg/L, with the most recent reported value of 3046 mg/L in 2012.
– One irrigation well is located 1.8 km southwest and is considered likely to be hydraulically cross-gradient. The site is located near a grass reserve next to the Noarlunga Aquatic and Recreational Centre within Noarlunga Centre. The other irrigation well is located 1.6 km east and is considered likely to be hydraulically up-gradient of the site in front of a house in a residential area.
– One well is listed as an “unknown” purpose, located along Christie Creek near the stormwater discharge point, which is considered potentially downgradient. The well is located on the opposite side of the creek to the site and was listed as installed in 1936. TDS was reported 1961 as 6138 mg/L, considered high TDS and unpalatable to humans (WHO, 2022).

2.4.3 Surface water use

Christie Creek receives stormwater discharge from the surrounding areas. A detailed assessment of the quality of this waterway is provided in Section F-3-2 of Appendix F. Based on the available information, it is considered unlikely that water is extracted for beneficial purposes.

The water level in Christie Creek is too low to support regular recreational activities involving full immersion in the water (e.g., swimming). Recreational activities, such as wading, may occur intermittently in Christie Creek. Fishing is unlikely to occur in Christie Creek, as it is characterised by shallow water depths and high inflow from stormwater discharge.

2.5 Ecological values of the Investigation Area

A search of the government-managed databases and tools, including the *NatureMaps* database and EPBC Act Protected Matters Search Tool (DCCEEW, 2024) (refer to Appendix F), indicates that there are no protected areas within the Investigation Area.

2.5.1 The Site (Zone 1)

The site currently has limited ecological value as it is covered mostly with hardstand from driveways and buildings as well as a gravelled area in the northeast corner inside the site fence. Outside the site fence is an unsealed area (~10m wide) adjacent to Holman Road and the reserve area. This area is mostly grass that appears to be mowed and a few shrubs.

While a potential low-density residential development or recreational land use could mean increased vegetation cover, the site will remain within an extensively built-up urban setting, far from surface water bodies and groundwater. Anthropogenic activities typically limit the presence of structural habitats and reduce the ecological value of the site.

2.5.2 Reserve area (Zone 2)

As described above in Section 2.2.2, the reserve area consists of grassed and mulched areas with scattered shrubs and young and mature trees. The reserve area ranges in width from 30 to 45 m, and the vegetation appears to be maintained, with evidence of the grass being mowed. Due to the high voltage overhead powerline, the growth of large trees may also be managed by the utilities providers to reduce possible impacts to the utility. During April 2024, the area appeared dry, with limited green grass and areas of exposed soil, as shown in Table 2.7.

No terrestrial species have been reported within Zone 2 in the NatureMaps and Atlas of Living Australia databases. Although the reserve area can support some plant life, it cannot support complex ecosystems given the scattered vegetation, use of the area for utilities and pedestrian traffic, and proximity to a major road (Flaxmill Road). More mobile species, such as reptiles and birds, may visit the area, but Zone 2 does not provide primary foraging habitat for these organisms.

Table 2.7 Zone 2 photographs from April 2024

	
Photograph A: North-west reserve area showing limited green grass and areas of exposed soil, facing south.	***Photograph B: North-eastern area showing limited green grass, facing east.***

2.5.3 The receiving environment (Zone 3)

The quality of surface water in South Australia is protected under the *Environment Protection (Water Quality) Policy 2015*. To facilitate the completion of an ERA in an aquatic environment, it is necessary to define the level of protection afforded a water body, which is based on considerations including the condition of the waterway, community values, and associated management goals. ANZG (2018) recognises three categories of current or desired waterway conditions, including:

- High conservation or ecological value systems (99% species protection) – effectively unmodified or highly valued ecosystems, typically occurring in national parks, conservation reserves, or remote and inaccessible locations.
- Slightly to moderately disturbed systems (95% species protection) – ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain healthy, and ecosystem integrity is largely retained.
- Highly disturbed systems (80-90% species protection) – measurably degraded ecosystems of lower ecological value, such as sections of harbours serving coastal cities and urban streams receiving road and stormwater runoff.

For the purpose of this report, Christie Creek has been classified as a slightly to moderately disturbed system based on the following:

- Christie Creek is an urban stream receiving large stormwater runoff volumes. The land use within the Christie Creek catchment is mainly urban and includes residential, recreational, and commercial/industrial land.
- As described in Appendix F, a GHD senior ecologist observed the following at locations along Christie Creek within the Investigation Area:
  - No observations of fish or large macroinvertebrates
  - Some sections with steep gradients create narrow drainage corridors and sections near busy roadways that would be less likely to provide appropriate nesting and foraging habitats for woodland bird species and reptiles.
  - Areas of the creek bank where erosion has occurred, including areas where the creek channel has been altered with rock gabions to manage erosion.
- No fish records and a limited number of amphibians in the Atlas of Living Australia (2024) database.
- Affected by heavy metals, particularly dissolved total chromium, copper, and zinc concentrations that exceeded the ANZG (2018) criterion for the protection of 95% of freshwater species at multiple locations.

3. Problem identification

The following discussion focuses on the PFAS sources, pathways and receptors relevant to the Investigation Area.

This section also presents a Tier 1 screening assessment of the dataset for the Investigation Area. The Tier 1 screening assessment process involves the comparison of the measured PFAS concentrations with the conservative human health and ecological screening levels provided by National or International Guidelines. The Tier 1 screening levels are designed to be well below the concentrations at which adverse health or environmental effects could occur. PFAS concentrations lower than these values are unlikely to present a risk to people and the environment. The Tier 1 screening process aimed to focus this Report on the PFAS exposure scenarios requiring more detailed assessment within subsequent sections.

3.1 Sources, pathways and receptors

3.1.1 PFAS sources

The primary source of PFAS at the site was the historical use and storage of AFFF containing PFAS. Historical activities associated with AFFF are as follows:

- Historical storage and use of PFAS-containing AFFF in training exercises.
- Washdown of equipment, trucks, and appliances.

Secondary sources of PFAS are currently present in the soils and concrete in Zones 1 and 2.

3.1.2 Migration pathways

The DSI (GHD, 2023a) indicates that PFAS is migrating offsite via the following pathways:

- Leaching of PFAS adsorbed to soil and concrete infrastructure during rainfall events and:
  - Surface water runoff, which primarily discharges to the public stormwater system, discharges into Christie Creek
  - Overland surface water runoff to Zone 2
- Airborne (spray) migration of AFFF solutions from the site to Zone 2 during historical AFFF use.
- Bioaccumulation in terrestrial and aquatic organisms.

Groundwater was not observed onsite to a depth of 20 m bgl; however, there is the potential that PFAS could migrate via:

- Leaching of PFAS adsorbed to soil and concrete infrastructure during rainfall events and vertical infiltration to deep, regional groundwater
- Groundwater flow and lateral migration.

3.1.3 Receptors and exposure pathways

The exposure pathways evaluated in this HHERA can be summarised as follows:

Human health

- Incidental ingestion of PFAS in surface soil by site users and Investigation Area users, including construction/maintenance workers (current and future).
- Inhalation of PFAS in soil or dust by site users and Investigation Area users.
- Consumption of produce (e.g. fruit and vegetables) grown within the site area (future), with PFAS bioaccumulation potentially occurring directly from soil.

– Incidental ingestion of PFAS in surface water and sediment by recreational users of Christie Creek (current and future).

Ecological receptors within the Reserve area and Christie Creek:

– Terrestrial organisms exposed to PFAS via direct contact with impacted soil and surface water or consumption of grasses and other flora by micro- and macro-fauna, which may be predated.
– Aquatic organisms exposed to PFAS via direct ingestion and surface water and sediment uptake.
– Higher trophic level aquatic and semi-aquatic species exposed to PFAS via the consumption of aquatic organisms (food chain exposure).

The following exposure pathways have been excluded from the HHERA:

– *Beneficial groundwater users* – Groundwater was not encountered at the site to a depth of 10.8 m bgl, and no groundwater strike was observed to 20 m bgl. Of the groundwater wells listed within the area, two are listed for irrigation and are located 1.6 km and 1.8 km from the site. These wells are considered hydraulically cross-gradient and up-gradient. Additionally, PFAS impacts in soil were not observed at MW10 at depths greater than 2 m bgl. As such, it is considered unlikely that a significant mass of PFAS would infiltrate deep groundwater and migrate to these wells.
– *Dermal exposure to PFAS* - Although the dermal absorption of PFAS can occur to a limited extent, dermal uptake makes a negligible contribution to PFAS exposure under normal circumstances (refer to Section C-2-5 of Appendix C). Specific consideration has, therefore, not been given in the HHRA to the dermal absorption of PFAS.

3.2 Nature and extent of contamination

The data presented in this section is based on the sampling undertaken within the Investigation Area, as presented in Appendix B. Sampling locations are shown in Figure 4 to Figure 5, Appendix A.

3.2.1 Adopted screening levels

The screening levels adopted for the Tier 1 assessment of risks to human users and the environment of the Investigation Area are summarised in Table 3.1.

Table 3.1 Summary of PFAS Tier 1 screening levels

Exposure scenario		PFHxS	PFOS	PFOS +PFHxS	PFOA	Source
Human health screening levels						
Zone 1 – The site, planned to be redeveloped for either low-density residential, medium-density residential or commercial/industrial purposes						
Soil and concrete	Future residents – low -density residential – Incidental ingestion or inhalation of soil/dust and produce consumption	0.01 mg/kg	0.01 mg/kg	0.01 mg/kg	0.1 mg/kg	HEPA (2020) Residential with accessible soil (HIL A)[1]
	Future site users – childcare centre - Incidental ingestion or inhalation of soil/dust and produce consumption	0.01 mg/kg	0.01 mg/kg	0.01 mg/kg	0.1 mg/kg	HEPA (2020) Residential with accessible soil (HIL A)[1]
	Future residents – medium-to-high-density residential – Incidental ingestion or inhalation of soil/dust	2 mg/kg	2 mg/kg	2 mg/kg	20 mg/kg	HEPA (2020) Residential with accessible soil (HIL B)[1]
	Future workers – commercial/industrial - Incidental ingestion or inhalation of soil/dust	20 mg/kg	20 mg/kg	20 mg/kg	50 mg/kg	HEPA (2020) Industrial / Commercial (HIL D)[1]
	Future site users – Incidental ingestion during recreational use	1 mg/kg	1 mg/kg	1 mg/kg	10 mg/kg	HEPA (2020) Recreational (HIL C) [1]
Zone 2 – Reserve area						
Soil	Incidental ingestion during recreational use	1 mg/kg	1 mg/kg	1 mg/kg	10 mg/kg	HEPA (2020) Recreational (HIL C) [1]
Zone 3 - Receiving environment (Christie Creek)						
Sediment	Incidental ingestion during recreational use	1 mg/kg	1 mg/kg	1 mg/kg	10 mg/kg	HEPA (2020) Recreational (HIL C) [1]
All zones						
Surface water and onsite discharges	Recreational users of Reserve area and Christie Creek	2 µg/L	2 µg/L	2 µg/L	10 µg/L	NHMRC (2019) Recreational water
Biota (fruit)	Human consumption			0.0006 mg/kg	0.0051 mg/kg	FSANZ (2017) Trigger Points for fruit
Ecological screening levels						
Soil	Direct exposures	-	1 mg/kg	-	10 (0.005)[2]mg/kg	HEPA (2020) Ecological direct exposure
	Indirect (food chain) exposures	-	0.01 mg/kg	-	0.005[3]	HEPA (2020) Ecological indirect exposure
Surface water	Direct exposures	-	0.13 µg/L	-	220 µg/L	HEPA (2020) Freshwater (FW) 95% species protection

		-	0.48 µg/L	-	-	ANZG (2023) FW 95% species protection
	Indirect exposure (food chain)	-	0.00023 µg/L	-	19 µg/L	HEPA (2020) FW 99% species protection
		-	0.0091 µg/L	-	-	ANZG (2023) FW 99% species protection
Notes: '-' indicates that no criteria were available; [1] HIL = health investigation levels; [2] Interim criterion for direct exposure to PFOA in soil for reptiles, based on the Draft PFAS 3.0 (HEPA, 2022); [3] Indirect exposure criterion for PFOA based on the Draft PFAS 3.0 (HEPA, 2022).						

Approach to the Tier 1 assessment of health risks due to PFAS in soil

The PFAS NEMP (HEPA, 2020) provides human health-based investigation levels (HILs) for the soil under four land use and exposure scenarios:

– *Residential with garden/accessible soil (HIL A)* – This includes incidental ingestion of soil and assumes that vegetable and fruit plants are grown at the property and homegrown produce provides up to 10% of fruit and vegetable intake (including sensitive uses, e.g. childcare).
– *Residential with minimal opportunities for soil access (HIL B)* – This includes incidental soil ingestion and assumes minimal fruit and vegetable production.
– *Public open space (HIL C)* – Relevant for public open spaces such as parks, playgrounds, and playing fields.
– *Industrial/commercial (HIL D)* – Relevant to industrial and commercial activities.

Five scenarios are proposed for the future redevelopment of the site, these are:

– Scenario 1 – The site is developed for low-density residential use.
– Scenario 2 – The site is developed for medium-to-high-density residential use.
– Scenario 3 – The site is developed for commercial/industrial.
– Scenario 4 – The site is developed as a childcare centre.
– Scenario 5 – The site is developed as an open space with recreational use.

As such, the following criteria has been applied to each scenario:

– HIL A for Scenario 1 (low-density residential) and 4 (childcare centre),
– HIL B for Scenario 2 (medium-to-high density residential),
– HIL C for Scenario 3 (commercial/industrial), and
– HIL D for Scenario 5 (open space with recreational use).

The PFAS NEMP (HEPA, 2020) does not provide assessment criteria specific to construction or maintenance workers; therefore, this scenario has been assessed separately.

Australian regulators have not endorsed screening levels for the Tier 1 assessment of PFAS in concrete or similar material. Without an alternative published alternative, the soil HILs have been adopted.

Approach to the Tier 1 assessment of ecological risks due to PFAS in soil

The PFAS NEMP (HEPA, 2020) ecological screening levels have been adopted as follows:

– *Ecological direct exposure* – The criterion (1 mg/kg) is based on the health-based HIL C, not ecotoxicity-based information, as the PFAS NEMP did not identify sufficient ecotoxicological data to derive a risk-based criterion specific to ecological receptors.
– *Ecological indirect exposure* – The criterion for PFOS (0.01 mg/kg) is based on the exposure of secondary consumers via the food chain.

The current PFAS NEMP (HEPA, 2020) does not provide an indirect exposure ecological criterion for PFOA in soil. However, the draft PFAS NEMP 3.0 (HEPA, 2022) recommends the following:

– An indirect exposure ecological criterion of 0.005 mg/kg
– An interim screening value of 0.005 mg/kg for PFOA where reptiles may be exposed directly to soil.

These guidelines have been adopted for completeness.

Australian regulators have not endorsed screening levels for the Tier 1 assessment of PFAS in concrete or similar material. Since paved areas do not provide habitats for ecological receptors, ecological criteria are irrelevant and have not been considered.

Approach to the Tier 1 assessment of ecological risks due to PFAS in water

The current ecological Water Quality Guideline (WQG) for PFOS, as presented in the PFAS NEMP (HEPA, 2020), was derived in 2015 as interim guideline values for PFOS. These values precede the publication of the Warne et al. (2018) methodology that underpins the ANZG (2018) WQG and do not incorporate ecotoxicity studies published in recent years. Due to the limitations of the current ecological WQG for PFOS, as presented in the PFAS NEMP (HEPA, 2020), these values are currently being updated. In May 2023, ANZG (2023) released a revised ecological WQG for PFOS for public consultation. For completeness, the PFAS NEMP and ANZG (2023) WQG have been adopted for this assessment.

As discussed in Section 2.5, Christie Creek is a slightly to moderately disturbed ecosystem. ANZG (2018) recommends that water quality guidelines (WQG) for the protection of 99% of species are adopted for the Tier 1 screening assessment of bioaccumulative substances such as PFAS in slightly to moderately disturbed ecosystems (rather than the 95% species protection values). This cautious approach to the assessment of bioaccumulative substances is suggested because WQG are typically derived based on ecotoxicity studies undertaken in the laboratory over relatively short durations, and these kinds of studies do not capture:

- The potential for higher trophic level aquatic and terrestrial species to experience harmful effects via food chain exposures (i.e., biomagnification) or
- The potential for bioaccumulative toxicants to be associated with intergenerational effects by maternal transfer of accumulated toxicants to offspring.

In this context, ANZG (2018) does not require the use of this more conservative approach to the Tier 1 screening assessment of bioaccumulative substances in circumstances where:

1. A separate weight-of-evidence (WoE) process is used to assess the potential for harmful indirect effects to aquatic and terrestrial species due to bioaccumulation or
2. The WQG is high or very high in reliability, and a significant proportion of the ecotoxicity studies used to derive the WQG are multigenerational (specifically > 30% of the ecotoxicity dataset and for > 3 taxa groups).

No aquatic biota samples have been collected during the field investigations (GHD, 2023a; 2024). The comparison of surface water analytical results with the WQG for the protection of 99% of species has therefore been used for the Tier 1 screening assessment of the potential for harmful effects to higher trophic level species via PFAS bioaccumulation in aquatic food chains (indirect exposure) (Point 1 above).

The ANZG (2023) draft of revised WQG for PFOS in freshwater systems included several chronic partial-generation, full-generation or multi-generation studies, with multigenerational studies available for eight of the 35 species (23%) included in the derivation of these values (Point 2 above). On this basis, it is considered reasonable to undertake the screening assessment of the risks associated with direct exposure to PFAS by lower trophic level organisms inhabiting Investigation Area waterways via the comparison of PFAS concentrations in water samples with the PFAS NEMP WQG for the protection of 95% of species.

Approach to the Tier 1 assessment of PFAS in sediments

To date, screening levels have not been endorsed by Australian regulators for the Tier 1 assessment of PFAS in sediments. The Tier 1 screening assessment of the health and ecological risks posed by the presence of PFAS in Investigation Area sediment has therefore been undertaken as follows:

- *Human health screening assessment*:
  - In the absence of an appropriate published alternative, the PFAS NEMP soil HIL C values for recreational land uses (HIL C) have been adopted for the screening assessment of sediments.
  - The HIL C values allow for daily contact with PFAS-impacted soil by young children for up to 2 hours. In this context, this approach is considered likely to be conservative in terms of the usage patterns of Investigation Area waterways.
- *Ecological screening assessment*
  - No relevant Tier 1 screening levels have been endorsed for sediment by Australian regulators. The analytical results obtained for sediment have, therefore, been assessed qualitatively.

3.2.2 Summary of the dataset

A consolidated dataset is provided in Appendix B, with sampling locations shown in Figure 4 to Figure 5, Appendix A. A summary of the samples collected and analysed for PFAS during the previous investigations is provided in Table 3.2.

Table 3.2 Summary of samples collected and analysed for PFAS

Zone	Soil	Concrete/ asphalt	Groundwater	Surface water	Sediment	Stormwater	Biota
Zone 1	57 (2 for ASLP[1])	2	Not encountered	Not applicable	Not applicable	Not applicable	2
Zone 2	54 (1 for ASLP and 1 for MEP[1] leachate)	3		Not applicable	Not applicable	Not applicable	0
Zone 3	Not applicable	Not applicable	Not applicable	Two sampling rounds with: – 7 samples were collected in dry conditions – 7 in wet conditions	One sampling round: – 7 samples were collected in dry weather	One sampling round with 3 samples collected from stormwater drains during wet conditions[2]	0

[1] ASLP – Australian Standard Leaching Procedure, MEP – Multiple Extraction Procedure

[2] Stormwater samples from the public stormwater drains on Holman Rd and Flaxmill Road

The following is noted concerning the rationale for the sampling undertaken:

Zone 1

– Soil sampling was focused on understanding the nature and extent of PFAS impacts in soil.

– The biota dataset was undertaken during the initial statewide sampling and was collected from lime and apricot trees that have since been removed from the site. Biota sampling did not attempt to collect sufficient samples to fully understand the PFAS bioaccumulation in the terrestrial environment of the Investigation Area.

Zone 3

– Samples were taken from 10 separate locations in Christie Creek upstream and downstream of the stormwater drain discharge point.

– During wet weather, a water sample was collected from inside the stormwater drain on Holman Road (STMWTR_01), which receives runoff from both Zone 1 and 2. Another sample was collected from within the stormwater system at a drain located on Flaxmill Road (STMWTR_02) that was determined, from the Data SA stormwater drains dataset, to be located along the stormwater system between the drain near the site and the outlet to Christie Creek (Government of South Australia, 2020). Closer to Christie Creek, the stormwater drain near the site runs parallel to another drain, and both discharge into Christie Creek. At the creek, two stormwater outlets are adjacent (shown in Table 2.5). Stormwater sample STMWTR_03 was collected from within the creek between the two drains.

3.2.3 Screening assessment outcomes

A consolidated dataset is provided in Appendix B. Sampling locations are presented in Appendix A.

A comparison of the PFOS, PFHxS and PFOA concentrations measured in the Investigation Area zones with the adopted screening levels is provided in Table 3.3 to Table 3.5.

Notably, the biota (fruit) samples are not pertinent to this risk assessment because the fruit trees have been removed from the site, rendering the exposure pathway incomplete. Nevertheless, the results are included for completeness.

Table 3.3 Tier 1 screening assessment of Zone 1 results

Parameter		PFHxS	PFOS	PFHxS+PFOS	PFOA
Soil					
Maximum soil concentration (mg/kg)		**0.31**	***3.8***	**3.829**	***0.028***
Screening Level	**Health guideline (HIL A)**	**0.01**	**0.01**	**0.01**	**0.1**
	Health guideline (HIL B)	2	2	2	20
	Heath guideline (HIL C)	1	1	1	10
	Health guideline (HIL D)	20	20	20	50
	Ecological guideline (indirect)	-	*0.01*	-	*0.005*
	Ecological guideline (direct)	-	1	-	10 (0.005)[a]
Concrete					
Maximum concrete concentration (mg/kg)		**0.15**	**0.23**	**0.38**	0.017
Screening Level	**Health guideline (HIL A)**	**0.01**	**0.01**	**0.01**	**0.1**
	Health guideline (HIL B)	2	2	2	20
	Heath guideline (HIL C)	1	1	1	10
	Health guideline (HIL D)	20	20	20	50
Biota (fruit trees are no longer present at the site)					
Maximum biota (lime) concentration (mg/kg)		0.001	<0.001	**0.001**	<0.001
Screening Level	**FSANZ (2017) Trigger Points for fruit**	**-**	**-**	**0.0006**	**0.0051**

Notes
Exceedances of the Tier 1 screening criteria are highlighted with relevant colours and fonts.
"-" indicates that no screening levels are available.
[a] Interim criterion for direct exposure to PFOA in soil for reptiles, based on the Draft PFAS 3.0 (HEPA, 2022)

Table 3.4 Tier 1 screening assessment of results from Zone 2

Parameter		PFHxS	PFOS	PFHxS+PFOS	PFOA
Soil					
Maximum soil concentration (mg/kg)		1.4	*11*	11.16	*0.16*
Screening Level	Health guideline (HIL C)	1	1	1	10
	Ecological guideline (indirect)	-	*0.01*	-	*0.005*
	Ecological guideline (direct)	-	1	-	10 (0.005)[a]
Bitumen					
Maximum bitumen concentration (mg/kg)		<0.005	<0.005	<0.005	<0.005
Screening Level	Health guideline (HIL C)	1	1	1	10
Stormwater					
Maximum stormwater concentration (µg/L)		0.029	0.051	0.08	0.003
Screening Level	**PFAS NEMP Recreational Water guideline** (NHMRC, 2019)	**2**	**2**	**2**	**10**

Notes
Exceedances of the Tier 1 screening criteria are highlighted with relevant colours and fonts.
"-" indicates that no screening levels are available.
[a] Interim criterion for direct exposure to PFOA in soil for reptiles, based on the Draft PFAS 3.0 (HEPA, 2022)

Table 3.5 Tier 1 screening assessment of results from Zone 3

Parameter		PFHxS	PFOS	PFHxS+PFOS	PFOA
Surface water					
Christie Creek – upstream of discharge point – maximum surface water concentration (µg/L)		0.005	0.0052	0.009	0.0092
Christie Creek – downstream of discharge point – maximum surface water concentration (µg/L)		0.016	0.0214	0.0373	0.009
Maximum of public stormwater system		0.029	0.051	0.08	0.003
Screening Level	PFAS NEMP 99% species protection	-	0.00023	-	19
	ANZG (2023) 99% species protection	-	0.0091	-	-
	PFAS NEMP 95% species protection	-	0.13	-	220
	ANZG (2023) *95% species protection*	-	*0.48*	-	-
	PFAS NEMP Recreational Water guideline (NHMRC, 2019)	**2**	**2**	**2**	**10**
Sediments					
Christie Creek – upstream of discharge point – maximum sediment concentration (mg/kg)		<0.005	<0.005	<0.005	<0.005
Dry Creek – downstream of discharge point – maximum sediment concentration (mg/kg)		<0.005	0.0059	<0.005	0.0059
Screening Level	Health guideline (HIL C)	1	1	1	10

Notes

Exceedances of the Tier 1 screening criteria are highlighted with relevant colours and fonts.

"-" indicates that no screening levels are available.

Summary of the Tier 1 HHRA and Tier 1 ERA are presented in Table 3.6 and Table 3.7, respectively:

Table 3.6 Summary of CSM for human receptors

Receptor	Exposure scenario	Exposure media	Exposure pathways	Evaluation of exposure pathway	Further risk assessment included
Zone 1 – MFS site					
Maintenance and construction workers	Intrusive work (e.g. installing pipework)	Soil	Incidental ingestion or inhalation of soil/dust.	PFAS concentrations in soil samples collected from Zone 1 were below the PFAS NEMP HIL D. Tier 1 screening levels specific to construction and intrusive workers are unavailable. Still, these works will typically be of short duration. A Construction Environmental Management Plan (CEMP) is recommended to mitigate exposure risks to construction and maintenance workers. Excavated impacted soils will need to be managed as per SA waste management guidelines.	No
Residents (future) – low-density residential	Residential with accessible soil, including production of homegrown fruit and vegetables	Soil	Incidental ingestion or inhalation of soil/dust. Consumption of homegrown fruit and vegetables.	PFOS, PFHxS, and PFOS+PFHxS concentrations in soil samples collected from Zone 1 exceeded the PFAS NEMP HIL A.	Yes PFOS, PFHxS and PFOS+PFHxS
Residents (future) – medium-to-high-density residential	Residential with limited accessible soil	Soil	Incidental ingestion or inhalation of soil/dust. No consumption of homegrown fruit and vegetables.	PFOS and PFOS+PFHxS concentrations in soil samples collected from Zone 1 exceeded the PFAS NEMP HIL B.	Yes PFOS and PFOS+PFHxS
Site users (future) – commercial/ industrial	Operation of the site	Soil	Incidental ingestion or inhalation of soil/dust.	PFAS concentrations in soil samples collected from Zone 1 were below the PFAS NEMP HIL D.	No
Site users (future) – childcare facility	Accessible soils and production of homegrown fruit and vegetables	Soil	Incidental ingestion or inhalation of soil/dust. Consumption of homegrown fruit and vegetables.	PFOS, PFHxS, and PFOS+PFHxS concentrations in soil samples collected from Zone 1 exceeded the PFAS NEMP HIL A.	Yes PFHxS and PFOS+PFHxS

Site users (future) - recreational	Recreational	Soil	Incidental ingestion or inhalation of soil/dust.	PFAS concentrations in soil samples collected from Zone 1 exceeded PFAS NEMP HIL C.	Yes PFOS and PFOS+PFHxS
Zone 2 – Reserve area					
Recreational users of Zone 2	Recreational activities	Soil	Incidental ingestion or inhalation of soil/dust.	PFOS and PFHxS + PFOS concentrations in soil samples collected from Zone 2 exceeded the PFAS NEMP HIL C.	Yes PFOS and PFHxS + PFOS
Maintenance and construction workers	Construction works	Soil	Incidental ingestion or inhalation of soil/dust.	PFAS concentrations in soil samples collected from Zone 2 were below the PFAS NEMP HIL D. Tier 1 screening levels specific to construction and intrusive workers are unavailable. Still, these works will typically be of short duration and will pose limited risk to human health. However, a Construction Environmental Management Plan (CEMP) is recommended to mitigate exposure risks to construction and maintenance workers. Excavated impacted soils will need to be managed as per SA waste management guidelines.	No
Zone 3 – Christie Creek					
Recreational users of the Investigation Area	Recreational activities in the receiving environment (Zone 4)	Sediment	Incidental ingestion	PFAS concentrations were below the PFAS NEMP HIL C.	No
		Surface water	Incidental ingestion	PFAS concentrations in surface water were below the NHMRC (2019) screening levels for the recreational use of water.	No

Table 3.7 Summary of the exposure scenarios progressed to the ERA

Receptor	Exposure scenario	Exposure media	Exposure pathways	Screening assessment outcomes	Further risk assessment warranted?
Zone 1 – MFS site					
Terrestrial organisms	Use of the site (Zone 1)	Soil	Direct ingestion and uptake	The PFOS+PFHxS concentrations measured in Zone 1 soils have generally been below or of the same order of magnitude as the PFAS NEMP direct exposure screening levels. Currently, most of the site is covered in concrete hardstand with limited ecological value. Under the proposed future land use scenarios of medium to high-density residential or commercial, most of the site would likely continue to be covered by hardstand. While the future use of Zone 1 had not been established at the time of reporting, human use will be the primary purpose rather than ecological values.	No
Zone 2 – Reserve area					
Terrestrial organisms	Use of the Reserve area	Soil	Direct ingestion and uptake	The soil samples collected from Zone 2 reported PFOS+PFHxS concentrations exceeding the direct soil exposure screening criteria for ecological receptors, with a maximum of 11 mg/kg. Notably, however, this guideline value is the HIL C value, as insufficient scientific evidence exists to establish a screening level specific to ecological receptors. Given the nature of Zone 2, a detailed assessment of direct exposure by terrestrial organisms is not considered warranted. 12 samples collected from Zone 2 reported PFOA concentrations up to 0.16 mg/kg, more than an order of magnitude above the draft direct exposure criterion for reptiles proposed by the draft PFAS NEMP 3.0 (HEPA, 2022) of 0.005 mg/kg. While reptiles may intermittently access the reserve area, it does not provide a complex foraging habitat and a more detailed assessment of risks to reptiles in this area is not considered warranted.	No
		Soil	Indirect exposure (food chain)	The majority of soil samples collected from Zone 2 reported PFOS+PFHxS concentrations above the Tier 1 screening levels for indirect exposure. Some soil samples also exceeded the PFOA draft indirect exposure criterion (HEPA, 2022) of 0.005 mg/kg. The indirect exposure values are of limited relevance if the area of exposed soil is too small to have any material impact on food chain transfer to secondary consumers such as invertivores and carnivores, as is the case within Zone 2. In this context, a more detailed assessment of risks to consumer organisms via the food chain is not warranted.	No
Zone 3 – Christie Creek					
Aquatic and semi-aquatic organisms	Use of Christie Creek	Surface water Sediment	Direct ingestion and uptake	All surface water samples collected from Christie Creek reported PFAS concentrations below the PFAS NEMP and ANZG (2023) WQG for the protection of 95% of species. PFOS+PFHxS was only detected in one sediment sample.	No
		Surface water	Indirect exposure (food chain)	All surface water samples collected from Christie Creek reported PFOS+PFHxS concentrations above the PFAS NEMP WQG for the protection of 99% of species. Three surface water locations collected reported PFOS+PFHxS concentrations above the ANZG (2023) WQG for PFOS for the protection of 99% of species of 0.0091 µg/L. PFOA concentrations were below the PFAS NEMP WQG for the protection of 99% of species.	Yes PFOS+PFHxS

Based on the available data, the extent of the PFAS impacts associated with the site can be summarised as follows:

– **Soil** – exceedances of relevant criteria for human health and ecological receptors are delineated and have not extended beyond Zones 1 and 2. Impacts have also been delineated vertically with deeper samples (>2 m bgl) reporting PFAS concentrations below the adopted health-based and ecological criteria.
– **Groundwater** – Groundwater was not observed at the site to a depth of 20 m bgl.
– **Sediment** – PFOS was detected in one sediment sample marginally above the laboratory limit of reporting (LOR). PFAS were not detected in the remaining sediment samples.
– **Surface water** – All concentrations were below the criteria for 95% but exceeded the criteria for 99%.

  During wet weather conditions, the PFAS concentrations in water sampled from within the drain located on Holman Road (STMWTR_01) were an order of magnitude higher than concentrations observed in Christie Creek and exceeded the ANZG (2023) WQG for PFOS for the protection of 99% of species of 0.0091 µg/L. During dry weather conditions, the surface water locations immediately downstream of the stormwater discharge outlet exceeded the ANZG (2023) WQG for PFOS for the protection of 99% of species of 0.0091 µg/L; however, all locations exceeded the PFAS NEMP WQG for the protection of 99% of species. It is noted that these locations also receive stormwater runoff from the Lonsdale industrial area located north of the creek, which may contribute to these PFAS impacts.

3.3 Evaluation and adequacy of the dataset

3.3.1 Data Quality

Evaluation of the quality of the data included in this HHERA is provided in the DSI (GHD, 2023a) and Supplementary DSI (GHD, 2024) and can be summarised as follows:

– Fieldwork was undertaken in general accordance with GHD standard operating procedures (SOPs), a set of uniform and systematic methods based on national guidance provided in the ASC NEPM and PFAS NEMP (HEPA, 2020).
– National Association of Testing Authorities (NATA) accredited laboratories performed laboratory analysis according to their quality assurance systems. Laboratory data validation (undertaken as part of the DSI and Supplementary DSI) included assessment of results for laboratory (method) blanks, laboratory control spikes, surrogate and matrix spikes and duplicate samples. These were compared against laboratory data quality limits. These were investigated and discussed where the results were outside of the recommended limits. GHD considers that the analytical and laboratory results outside the recommended limits acceptable.
– Field data validation assessed results for intra-laboratory and inter-laboratory duplicate samples, rinsate blanks, and trip blanks. These were compared against AS4482.1: 2005, NEPM 2013 - Schedule B(3), and Data Quality Objectives (DQOs).
– Based on the results of the laboratory QA/QC sampling analyses, it is considered that the data quality is suitable for its intended use and to meet the objectives of the investigation.

3.3.2 Dataset uncertainty and limitations

Key uncertainties and limitations of the available dataset include the following:

– Onsite soil sampling was limited to accessible areas and did not include areas covered by buildings. The soil results show some variability of PFAS concentrations across the site; however, the current soil dataset is insufficient to characterise variability across the entire site.
– There is uncertainty surrounding the temporal variability in the flux of PFAS from the MFS site via surface water into Christie Creek, where water flow may vary seasonally and in response to rainfall events. GHD completed two rounds of surface water sampling along Christie Creek, one under dry and one under wet conditions. Results showed that during dry conditions, PFAS concentrations in surface water downstream of the MFS site discharge point were an order of magnitude higher than those measured upstream, however, they returned to similar concentrations further down the river before exiting to the ocean. It is noted that

stormwater flow is the primary mechanism via which PFAS migrates from the site into Christie Creek, and short-term increases in the flux of PFAS through the Investigation Area may occur under certain conditions.

The potential for impacts to extend to the groundwater has not been confirmed via intrusive investigations; however, the existing geological data suggests that the soil impacts are unlikely to seep vertically into the groundwater as PFAS impacts in soil have been delineated vertically.

An HHRA has been conducted to assess the risks from direct exposure to PFAS-impacted soil in Zones 1 and 2, and it is presented below in Section 4. An ERA has been conducted to assess the risks of PFAS in stormwater runoff from the site impacting Christie Creek and the risk of PFAS accumulation in the food chains of the Christie Creek ecosystem. The ERA is presented in Section 5.

4. Human Health Risk Assessment

This section presents a Tier 2 human health risk assessment (HHRA) for the following scenarios:

– Zone 1 is used for low-density residential purposes, where residents may be exposed to PFAS via direct contact with soil and dust and by consuming vegetables and fruit produced within the property.
– Zone 1 is used for medium-to-high-density residential purposes, where residents may be exposed to PFAS via direct contact with soil and dust within a small garden area but where homegrown produce consumption is limited.
– Zone 1 is used for a childcare facility, where children and workers may be exposed to PFAS via direct contact with soil and dust and by consuming vegetables and fruit produced within the property.
– Recreational use of Zone 1 and Zone 2.

The primary focus of this Tier 2 HHRA is PFOS+PFHxS, which is the predominant PFAS identified in soil and surface water across the Investigation Area. A Tier 2 HHRA has not been undertaken for PFOA, as the Tier 1 HHRA did not identify PFOA concentrations above the relevant, health-based screening levels in the samples collected on and off-site. Other PFAS (including PFOA) have been considered in the uncertainty and sensitivity analysis (Section 4.4).

A Tier 2 HHRA has not been undertaken for the receiving environment (Zone 3) based on the outcomes of the Tier 1 screening assessment (refer to Section 3.2.3).

4.1 Toxicity assessment

A toxicity assessment determines whether human exposure to a chemical could cause an increase in the incidence of an adverse health condition (NEPC, 1999). The outcome of the toxicity assessment process is a set of toxicity criteria that are compared with exposure estimates to evaluate risk associated with chemical exposure pathways.

A detailed toxicity assessment for PFAS is presented in Appendix C. In accordance with the ASC NEPM (NEPC, 1999) Schedule B4, the toxicity assessment for this HHRA includes two elements:

1. *Hazard Identification*, which examines the toxicokinetic characteristics of PFOS+PFHxS and the capacity of PFOS+PFHxS to cause adverse health effects.
2. *Dose Response assessment* examines the quantitative relationships between PFOS+PFHxS exposure and health effects to determine the levels of exposure that could give rise to adverse impacts.

The toxicity assessment process characterised the absorption of PFOS+PFHxS and identified toxicity reference values (TRVs), a measure of tolerable daily exposure published by Food Standards Australia and New Zealand FSANZ (2017) for these chemicals. These parameters are summarised in Table 4.1.

Table 4.1 Summary of toxicological input parameters

Chemical	Toxicity assessment input parameters	Source
Toxicity reference values		
PFOS, PFHxS (sum)	20 ng/kg/day*	FSANZ (2017)
Absorption parameters		
Dermal absorption	Low (assumed at 0.01 unitless)	OEH (2019); ATSDR (2021); EFSA (2020)
Gastrointestinal absorption	100%	FSANZ (2017)
* ng/kg/day is nanograms per kilogram of body weight per day		

4.2 Human exposure assessment

The exposure assessment process aims to estimate the chemical exposures experienced by the receptors identified in the CSM (NEPC, 1999).

4.2.1 Exposure scenarios

The exposure scenarios included in this HHRA are summarised in Table 4.2.

Table 4.2 Summary of exposure scenarios included in the HHRA

Scenario	Exposure scenario	Exposure pathway
Future residents/users of Zone 1		
Low-density residential land is used with accessible soil for growing edible vegetables and fruits and for the consumption of homegrown products.	Direct contact with soil and dust	Incidental ingestion and inhalation
	Consumption of produce (e.g., fruit and vegetables) accumulating PFAS from soil.	Domestic consumption of homegrown produce
Medium-to-high-density residential land is used with minimal accessible soil and no consumption of homegrown fruit and vegetables.	Direct contact with soil and dust	Incidental ingestion and inhalation
Childcare facility with accessible soil and possibly growing edible fruit and vegetables for consumption.	Direct contact with soil and dust	Incidental ingestion and inhalation
	Consumption of produce (e.g., fruit and vegetables) accumulating PFAS from soil.	Domestic consumption of homegrown produce
Recreational use	Direct contact with soil and dust	Incidental ingestion and inhalation
Users in Zone 2		
Recreational use	Direct contact with soil and dust	Incidental ingestion and inhalation

The HHRA did not include the production and consumption of poultry eggs or other livestock products in Zone 1 due to the limited size of the lot and the highly urbanised settings.

4.2.2 Exposure parameters

The approaches outlined in the ASC NEPM (NEPC, 1999) have been used to select exposure assessment inputs that are adequately protective of future residents of Zone 1 and workers labouring within Zone 2, as follows:

– General physical characteristics and dietary ingestion rates have been sourced from the ASC NEPM (NEPC, 1999), enHealth (2012a; 2012b) and FSANZ (2017).

– The ASC NEPM (NEPC, 1999) Schedule B7 provides behavioural and exposure duration assumptions for standard exposure scenarios, and the values relevant to residential settings have been adopted.

– In the calculations of HIL A guidelines, the ASC NEPM assumes that households could source an average of 10% of their fruit and vegetables from domestic sources. This assumption has also been adopted in this assessment, although it is likely to be conservative in the context of the site redevelopment.

– The fruit and vegetable consumption rates used by OEH (2019) to derive the PFAS NEMP HILs have been used to estimate the risks associated with the domestic consumption of produce (refer to Appendix E).

– Exposures to PFOS+PFHxS may be associated with releases attributable to identified sources of contamination and impacts that originate from other sources in the wider environment and exposure in occupational settings. A background exposure assumption of 10% has been adopted in this assessment as a reasonable representation of the long-term background exposures experienced by the Australian population (refer to Appendix D for more details).

The exposure parameters incorporated Into the HHRA are detailed in Appendix E. The uncertainty associated with key exposure parameters has been evaluated in the Sensitivity Analysis (Section 4.4).

4.2.3 Exposure assessment calculations

The modelling algorithms used to estimate the PFAS exposures for future residents and construction/maintenance workers, as well as the modelling inputs and outputs, are provided in Appendix E.

A detailed description of the modelling approach used to estimate the transfer of PFAS from soil into homegrown produce, as well as direct contact with soil and dust, is provided in Appendix D.

4.2.4 Exposure point concentrations

Exposure point concentrations (EPC) are the contaminant concentrations used in a quantitative HHRA to estimate exposure. The GHD investigations have included the analysis of PFAS in soil samples collected in Zone 1 and 2 (Section 3.2).

Due to the relatively limited number of data points and sampling rounds available from Zone 1, the exposure estimates in this HHRA have been based on the maximum PFOS+PFHxS concentrations measured in the soil in this area.

Within Zone 2, a significant number of soil samples were collected. Therefore, the 95% upper confidence limit (UCL) of the mean PFOS+PFHxS was calculated using the US EPA ProUCL software and adopted at the EPC. A 95% UCL was not calculated for Zone 1 as the soil dataset was unsuitable, as discussed in Section 3.3.2. The EPC for Zone 1 and Zone 2 are summarised in Table 4.3.

Table 4.3 Exposure point concentrations used in HHRA modelling

Location	Media	Relevant sample IDs	Maximum PFOS+PFHxS concentration	Fraction of PFHxS (% of PFOS+PFHxS)	95% UCL
Zone 1	Soil	BH27_0.4-0.5	3.82 mg/kg	0.75%	Not calculated
Zone 2	Soil	SS10	11.16 mg/kg	3.9%	10.89 mg/kg[1]
[1] 95% UCL was calculated based on locations with accessible soil and samples taken between the surface to 0.5 m bgl to represent possible exposure concentrations.					

4.3 Risk characterisation

In this HHRA, the risk characterisation process combines the toxicity and exposure assessment results to estimate the risks associated with exposure to PFAS within Zones 1 and 2.

4.3.1 Methodology

To evaluate whether the PFAS concentrations measured in Zone 1 could represent a health risk, the TRVs detailed in Section 4.1 were compared with the PFAS intake rates calculated via the methodology outlined in Section 4.2.2. Specifically:

– The ratio of the estimated PFOS+PFHxS intake to the PFOS+PFHxS TRV was calculated for each exposure pathway. This ratio is termed a Hazard Quotient (HQ).
– All the HQs were summed to derive an overall Hazard Index (HI).

A degree of conservatism is built into the toxicity and exposure assessment processes, and therefore, the calculated HIs have been interpreted as follows.

– HI ≤1: Indicates an exposure scenario where there is a low risk that PFOS+PFHxS intake will exceed the TRV
– HI >1 and ≤10: Indicates an exposure scenario where there is a moderate risk that PFOS+PFHxS intake will exceed the TRV
– HI >10: Indicates an exposure scenario with a high risk that the PFOS+PFHxS intake will exceed the TRV.

The equations used in the risk characterisation process are outlined in Appendix E.

4.3.2 Zone 1 outcomes

The site zoning allows for a range of potential future uses, including residential land use and various associated supporting services (commercial and recreational land uses and care facilities). The CSM (Section 3.2.3) identified a low risk that the site's future use for commercial activities (e.g., retail premises) would be associated with PFOS+PFHxS intakes above the TRV. The CSM concluded, however, that further consideration of the risks associated with the potential future residential use of the site and the use of the site for a care facility (e.g. a childcare centre) was warranted.

The most sensitive receptor across residential and childcare settings is a child, as children typically demonstrate higher contaminant intake to body weight ratios and a greater tendency to ingest soil during activities such as play. Both residential and childcare uses could potentially involve individual children spending the majority of their waking hours on site, with the primary factors that will influence the extent of PFAS exposure being:

– The extent to which produce (e.g. fruit and vegetables) are produced onsite and consumed.
– The extent to which exposed surface soil can generate dust and be directly accessed by children using outdoor areas.

As the site's future use is unknown, the risk characterisation process for Zone 1 has focused on defining what patterns of land use could be associated with PFOS+PFHxS intakes above the TRV and which patterns of land use would be associated with low risk. This analysis is presented in Table 4.4.

Table 4.4 Summary of risk characterisation – users of Zone 1 – residential land use

Exposure scenario	Hazard Quotient - Children		
	Exposure pathway	Residential setting [1]	Childcare setting [2]
Direct exposure pathways			
Large garden (25% of site is exposed soil)	Inhalation of soil and dust	4.6E-04	1.0E-04
	Incidental ingestion of soil	1.1E+00	7.4E-01
Small garden (17.5% of site is exposed soil)	Inhalation of soil and dust	4.3E-04	8.8E-05
	Incidental ingestion of soil	7.0E-01	4.6E-01
Minimal garden (10% of site is exposed soil)	Inhalation of soil and dust	2.8E-01	7.1E-05
	Incidental ingestion of soil	4.0E-04	1.8E-01
Produce consumption			
10% of diet	Home-grown produce consumption	**2.0E+01**	
5% of diet		**1.0E+01**	
1% of diet		**2.0E+00**	
[1] 365 days per year onsite			
[2] 240 days per year onsite			

Table 4.4 demonstrates that:

– There is a low risk that the intake of PFOS+PFHxS by child users of the site will exceed the TRV if the site is redeveloped in such a way that direct contact with soil is limited. Examples of these kinds of developments would include a medium-to-high-density residential development, where the majority of the site is covered with buildings, paving or limited landscaped areas.

  This outcome reflects the limited volatility of PFOS+PFHxS and that exposure primarily occurs in association with the incidental ingestion of soil (e.g. hand-to-mouth actions).
– There is a moderate to high risk that the intake of PFOS+PFHxS by child users of the site could exceed the TRV if the site is redeveloped in such a way that there is a reasonable amount (e.g., greater than 17.5%) of exposed soil.
– The consumption of even a relatively small amount of produce grown on the site could be associated with intakes of PFOS+PFHxS above the TRV.

It is noted that only a limited number of soil samples have been collected from the site to date. That temporal variability in onsite PFAS impacts is not well understood. While the overarching outcomes of the risk characterisation process would remain valid across a range of onsite soil conditions, additional onsite soil investigations will be required to inform the development and remediation planning process.

A future recreational use scenario for the site has also been considered quantitatively in this HHERA with a HQ of 0.6. This outcome suggests a low risk that the site's redevelopment for recreational use would be associated with a health risk. There is, however, a high degree of uncertainty associated with this outcome, given the limited soil sampling undertaken to date and the potential for a recreational setting to include large areas of exposed surface soil.

Overall, the risk characterisation outcomes for Zone 1 suggest that the PFAS intake associated with exposed surface soil should be considered when defining the remedial and proposed future land use options for the site. Specifically, extensive remedial work would be required if a future onsite redevelopment incorporated significant areas of exposed onsite soil and the potential for a food-producing garden.

4.3.3 Zone 2 outcomes

The maximum and 95% UCL PFOS+PFHxS soil concentrations of 11.16 mg/kg and 10.89 mg/kg within Zone 2 exceed the PFAS NEMP HIL C of 1 mg/kg. This section presents a qualitative HHRA for Zone 2.

A review of the available data indicates that the risk associated with PFAS exposure from recreational use of Zone 2 is low based on the following lines of evidence:

1. **The use of the reserve is limited under both the current and expected conditions**. The reserve includes walking tracks connecting the northern residential area to the shopping centre to the east and Flaxmill Road to the south. It is not a designated council parkland and lacks playground equipment, amenities, or other park facilities. This would discourage people to spend extended periods within Zone 2 in direct contact with soil.

   Nipu-nipu Wama/Morton Park is located approximately 100 m south of the site and offers various recreational options, including an oval, playgrounds, a skate park, tennis courts, public amenities, and community building.
2. **HIL C does not directly apply to non-recreational open spaces, such as road reserves** –HIL C assumes that young children use the area to be assessed for frequent short periods (two hours a day, seven days a week). Based on the point above, this is not the case for the reserve. The presence of overhead and underground services within Zone 2 also means that more intensive use of this area is unlikely.
3. **Localised PFAS exceedances** – The soil dataset for Zone 2 is robust, with soil samples collected from 30 locations. The dataset shows spatial variability in PFAS concentrations with exceedances of the HIL C (1 mg/kg) reported in only five locations installed within the unsealed reserve areas where direct access is possible.

Overall, the weight of evidence indicates that exposure to PFAS-contaminated soil in Zone 2 is limited, and the risk to human users of Zone 2 is low. It will, however, be important to consider other factors in the planning for the management of the PFAS-impacted soils in Zone 2, including stakeholder perceptions around the presence of elevated PFAS levels in publicly accessible land, the role of this area as an ongoing source of PFAS to the surrounding environment and the requirement for PFAS-impacted soil to be managed appropriately during intrusive work.

4.4 Uncertainty and sensitivity analysis

The uncertainty analysis identifies the assumptions and data gaps associated with the HHRA. The main areas of uncertainty identified for this assessment include:

– Exposure Assessment – variability in future residents' land use patterns
– Toxicity Assessment – a range of TRV have been adopted internationally for PFOS and PFHxS.
– Risk Characterization – reliance on modelling approaches to estimate PFAS exposure risks.

The approaches used to reduce the uncertainty associated with this HHRA have been to use site-specific data wherever possible and to adopt conservative assumptions from reputable Australian and international agencies in the absence of site-specific data. In addition, it is noted that the maximum PFOS+PFHxS concentration in soil measured in Zone 1 was adopted as the EPC, which is likely to be conservative.

Given the factors outlined above, the uncertainty in this assessment has been considered by erring on the side of the overestimation of potential health risks.

Key areas of uncertainty, which could influence the outcomes of the HHRA, include:

– The limited information that is currently available regarding the future use of the site
– The presence of PFAS other than PFOS and PFHxS in the environment.
– Spatial variability in PFAS concentrations in soil and the limitations of the current onsite soil dataset.
– Uncertainty regarding the toxicity endpoints for PFAS

These areas of uncertainty should be considered in the development and PFAS management and remediation process. Specifically:

– Additional soil sampling will be required to characterise the PFAS impacts on the site further and support future development and remediation planning.
– Future development and remedial planning should consider the specific details of the proposed future site use when this information is available.
– The NHMRC[2] has recently released updated drinking water guideline values for PFAS, which indicate that the amount of PFAS in drinking water that a person can consume daily over a lifetime without any appreciable health risk is lower than that allowed for in the current NHMRC (2011) drinking water guidelines. These guidelines have not been finalised, and their implications for PFAS in soil have not yet been established, creating uncertainty. Notwithstanding this, however, future onsite development options that limit exposed surface soil will effectively limit the potential for exposure.
– PFAS other than PFOS, PFHxS and PFOA have been identified in soil, which also creates a level of uncertainty. The soil samples that have reported PFOS and PFHxS concentrations > 1 mg/kg other PFAS have made a relatively small contribution to total PFAS concentrations (generally <30%), such that their presence does not change the assessment outcomes. However, It will be important to consider the range of PFAS present in soil during any future sampling efforts.

Another area of uncertainty is the lack of groundwater data. Groundwater was not encountered during drilling at the site to 20 m bgl and was not observed in the groundwater well (MW01). There is the potential that, given that the regional groundwater is a fractured rock aquifer, MW01 did not intersect a water-bearing fracture. However, considering the regional topography, surrounding urban land use, and the fact that the area is supplied with mains water, it is unlikely that groundwater will be intersected by future redevelopment, and further groundwater investigation has not been proposed.

[2] https://consultations.nhmrc.gov.au/environmental-health/australian-drinking-water-guidelines-2024-pfas/

5. Ecological Risk Assessment

This section presents an ERA for the aquatic environment of Christie Creek downstream of the MFS site.

In Section 3, the PFAS NEMP ecological screening levels were used to provide a Tier 1 assessment of direct and indirect (food chain) risks that could occur in association with the presence of PFAS in Christie Creek. The results of this screening assessment can be summarised as follows:

– The PFOS, PFHxS, and PFOA concentrations measured in the receiving environment of Christie Creek have been below the PFAS NEMP WQG for the protection of 95% of species. **Therefore, Direct exposure to PFAS represents a low risk to aquatic organisms inhabiting the receiving environment, which has not been considered in detail in this ERA**.
– The PFOS and PFHxS concentrations measured in the receiving environment of Christie Creek have generally been above the PFAS NEMP WQG for the protection of 99% of species. **This ERA has, therefore, evaluated whether PFAS impacts may represent a risk to aquatic food chains in the areas downstream of the site.**

This ERA is focused on PFOS and PFHxS, the main PFAS detected in the Investigation Area. Other PFAS are discussed qualitatively in Section 5.3.

5.1 Receptor identification

The receptor identification process focuses on identifying the species at risk and the ecological values that must be protected (NEPC, 1999). Due to the diversity of species present within the environment, it is not possible to undertake a detailed evaluation of ecological risk for all flora and fauna exposed to PFAS. However, in this ERA, site-specific information has been used to identify local species or communities that are most sensitive and representative of a broader class of organisms that may be present.

The ecological receptors relevant to the investigation area have been identified based on government-managed databases and tools and an ecologist's inspection of the investigation area. Appendix F provides a detailed summary of this information.

Table 5.1 summarises the ecological receptor groups that may be exposed to PFAS via the food chain in the receiving environment.

Table 5.1 Summary of receptor groups present in Zone 3 – aquatic environment

Receptor group	Primary exposure mechanism	Zone 3 – Christie Creek
Semi-aquatic birds and waterbirds	Bioaccumulation and dietary exposure (food chain)	Various bird species have been observed along Christie Creek within the Investigation Area. Species that may feed on aquatic macroinvertebrates, amphibians and small-sized fish (if present) include the little pied cormorant (*Microcarbo melanoleucos),* white-faced Heron (*Egretta novaehollandiae*), and hoary-headed grebe (*Poliocephalus poliocephalus).*
Semi-aquatic mammals		Aquatic mammals such as the platypus (*Ornithorhynchus anatinus)* were not observed along Christie Creek, but the creek may provide habitat for semi-aquatic mammals such as water rats (*Hydromys chrysogaster*)
Aquatic and semi-aquatic reptiles and amphibians		Aquatic or semi-aquatic species not observed by GHD but which may be present in Christie Creek include the common froglet (*Crinia signifera*) and banjo frog (*Limnodynastes dumerilii*).

5.2 ERA for aquatic environments (Zone 3)

This section qualitatively assesses food chain exposure risks to higher trophic level organisms inhabiting Christie Creek. No biota data is available to support a quantitative assessment.

A detailed description of Christie Creek is provided in Appendix F. As outlined in Section 5.1, the organisms that may be exposed to PFAS within Christie Creek include terrestrial birds that consume aquatic organisms (e.g. kookaburra), waterbirds (e.g. white-faced heron), semi-aquatic mammals (e.g. water rat), reptiles (e.g. turtles) and amphibians.

The weight of evidence process involves evaluating qualitative, semi-quantitative, or quantitative evidence to assess the quality of an aquatic system (ANZG, 2018). It requires assessing the data's quality, quantity, relevance, and congruence from various sources.

Nature and extent of impacts

The PFOS+PFHxS concentrations measured in the 14 surface water samples collected from ten locations along Christie Creek under dry and wet conditions exceeded the PFOS criterion for protecting 99% of species of 0.00023 µg/L. The concentrations ranged between 0.0081 and 0.0373 µg/L during dry conditions and between 0.0025 and 0.006 µg/L during wet conditions.

The concentrations downstream of the discharge point were marginally higher than those measured upstream locations during the dry weather event when there was no run-off from the site or reserve area. However, a clear distinction was not apparent in the dataset between the upstream and downstream locations during the wet weather event, as illustrated in Table 5.2. This reflects the presence of sources of PFAS within the wider catchment. For example, as described in Section 2.2.3, the Lonsdale commercial/industrial area is located north of Christie Creek near the stormwater discharge point from the site. Stormwater from this area discharges to Christie Creek and may contribute to the PFAS flux in the creek (i.e., ambient PFAS concentrations).

Stormwater samples were collected from within the stormwater pits during the wet weather event, as shown in Table 5.2. These showed that runoff from Zone 1 and 2 collected at the downgradient stormwater drain (STMWTR_01) had a PFOS+PFHxS concentration of 0.08 µg/L, which was likely diluted in the stormwater drainage system to concentrations of 0.0022 and 0.0060 µg/L (at STMWTR_02 and STMWTR_03), before discharging to Christie Creek

Table 5.2 Summary of PFAS results in stormwater and surface water samples

Location		Sum of PFHxS and PFOS (µg/L)		PFAS (Sum of Total) (µg/L)	
		Apr-24	Jul-24	Apr-24	Jul-24
		Dry	Wet	Dry	Wet
STMWTR_01	Stormwater drain, downgradient Zone 1 and 2.	-	0.080	-	0.187
STMWTR_02	Stormwater drain between the site and discharge point	-	0.0022	-	0.0362
STMWTR_03	Located in Christie Creek, near a stormwater discharge point	-	0.006	-	0.011
SW03	Located in Christie Creek, near STMWTR_03	0.031	-	0.064	-
SW01/ SW11 (Collocated)	Downstream of stormwater discharge point (<500 m from discharge point)	0.029	0.0044	0.083	0.0094
SW02/ SW10 (Collocated)		0.032	0.004	0.089	0.009
SW12	Downstream of stormwater discharge point (>500 m from discharge point)	-	0.005	-	0.012
SW13		-	0.005	-	0.012
SW14		-	0.005	-	0.012
SW04/ SW09 (Collocated)	Upstream of stormwater discharge point	0.0082	0.0026	0.0462	0.0066
SW05/ SW08 (Collocated)		0.0081	0.0025	0.0331	0.0075
SW06		0.0092	-	0.0362	-

Location		Sum of PFHxS and PFOS (µg/L)		PFAS (Sum of Total) (µg/L)	
		Apr-24	Jul-24	Apr-24	Jul-24
		Dry	Wet	Dry	Wet
SW07		0.0092	-	0.0262	-

Limited information is available about the ambient levels of PFAS in South Australia. However, according to the draft PFAS NEMP 3.0 (HEPA, 2022), the levels of PFAS in the environment will likely vary depending on the type and intensity of land use. The PFOS concentrations identified via the ambient sampling programs undertaken in Victoria and Queensland, as detailed in the draft PFAS NEMP 3.0, are summarised in Table 5.3.

Table 5.3 Summary of ambient monitoring undertaken in Victoria and Queensland (HEPA, 2022)

Catchment land use	Victorian sampling program outcomes		Queensland sampling program outcomes	
	Range of PFOS concentrations (µg/L)	Sites with PFOS detections (%)	Range of PFOS concentrations (µg/L)	Sites with PFOS detections (%)
Remote (>85%)	<0.0002 to 0.0002	20%	<0.0001 to 0.0001	11%
Agricultural (>60%)	<0.0002 to 0.009	75%	<0.0001 to 0.0011	53%
Urban (>40-50%)	0.0007 to 0.081	100%	<0.0001 to 0.037	83%

The data presented in Table 5.3 aligns with the data collected in Christie Creek, demonstrating that, while PFAS are man-made chemicals, they are often present in aquatic environments in urban areas due to the diversity of purposes they have been used (refer to Section 1.4).

The presence of PFAS in samples collected upstream of the site within Christie Creek highlights the limited value of the PFAS NEMP 99% species protection value for PFOS in urban settings, where PFAS is ubiquitous.

Overall, the water samples collected to date do not suggest that the stormwater discharges from the site are likely to materially influence the extent to which PFAS is bioaccumulating in the aquatic food chain of Christie Creek relative to those related to other sources. This likely reflects the relatively limited spatial extent of the PFAS impacts at the site relative to the broader urban catchment, the significant distance between the site and the receiving environment, the limited extent to which groundwater migration appears to contribute to PFAS migration in this setting and the presence of large areas of hardstand within Zone 1 and Zone 2.

Relevance of the water quality guideline

It is also noted that while the PFOS+PFHxS concentrations in Christie Creek (between 0.0025 and 0.0373 µg/L) are one to two orders of magnitude above the PFAS NEMP 99% species protection value of 0.00023 µg/L, they are of a similar order of magnitude to the 99% species protection value of 0.0091 µg/L proposed by ANZG (2023).

In recent months, the federal Department of Climate Change, Energy, the Environment and Water (DCCEEW) (Dawson, Le-Steere, Mann, Stauber, & Vardy, 2024) has released an independent review of the ANZG (2023) draft PFOS DGV, which identified a number of specific technical issues. The DCCEEW review recommended the removal of several studies from the ecotoxicity dataset used to derive the PFOS WQG, including several studies at the lower end of the species sensitivity distribution. As such, the updates recommended by the DCCEEW would significantly increase the PFOS WQG, although the final WQG had not been established at the time of reporting.

As outlined in Section 3.2.1, using the 99% species value in the Tier 1 screening assessment of slightly to moderately disturbed waterbodies is a precautionary approach rather than a mechanistic link to food chain exposure risks. Based on the results summarised in Table 5.2, it is likely that some bioaccumulation of PFAS occurs in lower trophic level organisms inhabiting Christie Creek, both upstream and downstream of the site. The weight of available evidence does not suggest that there are likely to be measurable adverse effects on higher trophic-level organisms (described in Appendix F-3-2) that may access the Christie Creek area (e.g., waterbirds), noting that:

– A clear indication of a measurable impact of the site on PFAS concentrations in Christie Creek surface water is not apparent in the dataset collected to date.

– The creek's ecosystem has been significantly disturbed by human activity, including alterations of the channel (installation of dams and weirs) and the surrounding (e.g., riparian) systems, as well as the discharge of urban stormwater characterised by poor water quality (Appendix F).
– Many invasive species were present along the creek, with limited native vegetation remaining, which impacted the system as a whole. A lack of native vegetation results in reduced habitat for native species and erosion along the banks.

Whilst PFAS impacts appear minimal in Christie Creek, the primary migration pathway from the site is runoff collecting in the stormwater drainage system and discharging into Christie Creek. Future development and PFAS remediation and management activities in Zone 1 and Zone 2 that limit the presence of PFAS in exposed surface soil will also reduce the migration of PFAS via stormwater runoff.

5.3 Uncertainty and sensitivity analysis

5.3.1 ERA uncertainty analysis

. The main areas of uncertainty identified for this assessment include:

– *Scenario uncertainty,* including incomplete information about the habits of ecological receptors.
– *Parameter uncertainty,* including temporal and spatial variability in the PFAS concentration in abiotic media.

These are discussed herein.

Temporal and spatial adequacy

While seasonality is captured to a certain extent in the dataset, there are limitations to the dataset regarding evaluating the impact of variability in surface water flow on the flux of PFAS through the Investigation Area, both from the site and the wider catchment.

GHD investigations involved surface water sampling under dry (low flow) and wet (flowing) conditions. Given that stormwater flow is the primary mechanism via which PFAS migrates from the site into Christie Creek, it was expected that during periods where there is an increase in the flow of stormwater from the site into Christie Creek, there would likely be short-term increases in the flux of PFAS through the Investigation Area. Similarly, PFAS flux through the Investigation Area, resulting from stormwater inputs across the wider catchment, would also increase during wet weather events.

Slightly higher PFAS concentrations were observed downstream of the discharge point during the dry weather sampling, where there was no run-off from the site, which may suggest additional sources of PFAS. During the wet weather event, PFAS concentrations in Christie Creek downstream of the site were comparable to those measured upstream. Notably, all stormwater and surface water samples reported PFAS concentrations below the 95% species protection values.

The spatial distribution of sampling locations is considered appropriate, as surface water samples were collected at the discharge point and upstream and downstream of the site, providing consistent results.

Overall, the dataset is considered adequate from both a temporal and spatial perspective to inform an understanding of risks to the environment of Christie Creek.

Presence of other PFAS

This ERA focuses on PFOS, PFHxS and PFOA, which are the PFAS with Australian guidelines. Various PFAS other than PFOS and PFHxS have been identified in soil, surface water, sediment and biota. Consideration has also been given to the presence of PFAS other than PFOS+PFHxS within the Investigation Area.

The concentration of total PFAS in surface water samples collected from Christie Creek was lower than the PFAS NEMP (HEPA, 2020) 95% species protection value of 0.13 µg/L. Hence, the presence of other PFAS would not change the outcomes of the Tier 1 ERA. It is noted that the total PFAS in the stormwater pit downgradient of the site had a concentration of 0.187 µg/L, exceeding the 95% species protection; however, concentrations reduced before discharging to the creek.

Limited ecological survey data

Detailed ecological surveys or studies were not undertaken as a component of this ERA, and investigation area data on the structure and function of the communities was limited. While this limitation is acknowledged, a study of this complexity was outside the scope of this ERA. A more detailed ecological survey is also not warranted, given the results of the investigations undertaken in Christie Creek.

6. Summary of Outcomes

GHD was engaged to conduct an HHERA to evaluate the presence of PFAS at the MFS Christie Downs Fire Station (Zone 1), its immediate surroundings to the east (Zone 2), and sections of Christie Downs receiving stormwater from the site (Zone 3). Collectively, these three zones are referred to as the Investigation Area. The HHERA assessed the human health and ecological risks associated with PFAS in soil in Zones 1 and 2 and in sediment and surface water in Zone 3.

Objectives of the HHERA

The overarching purpose of the works undertaken by GHD is to assist MFS in managing the identified PFAS impacts in the context of the site's proposed divestment and redevelopment and the relevant adjacent land uses and receiving environments.

Specifically, the primary objective of this HHERA is to assess the potential risks to human health and the environment that may be associated with PFAS contamination within the Investigation Area under the land use patterns that are possible for the onsite area in the future, including the following:

– Scenario 1 – The site is developed for low-density residential use.
– Scenario 2 – The site is developed for medium-to-high-density residential use.
– Scenario 3 – The site is developed for commercial/industrial.
– Scenario 4 – The site is developed as a childcare facility.
– Scenario 5 – The site is developed as open space with recreational use.

It is noted that there is no expectation that the land use in the offsite areas of the Investigation Area (including Zones 2 and 3) will change in association with the future onsite redevelopment.

Outcomes for Zone 1 (Former MFS site)

The key outcomes of the HHERA undertaken for Zone 1 can be summarised as follows:

– The consumption of even a relatively small amount of produce grown on the site could be associated with intakes of PFOS+PFHxS above the tolerable daily levels defined by Australian health and environmental regulators.
– There is a low risk that the intake of PFOS+PFHxS by future site users will exceed the tolerable daily levels defined by Australian health and environmental regulators if the site is redeveloped in such a way that direct contact with soil is limited.
– Examples of developments that would minimise direct contact with soil include medium-to-high-density residential developments or commercial developments, where most of the site is covered with buildings and paving.
– These outcomes reflect the limited volatility of PFOS+PFHxS and the fact that exposure to PFAS in soil primarily occurs in association with the incidental ingestion of soil (e.g. hand-to-mouth actions) and the bioaccumulation of PFAS in homegrown food.
– On-site soil sampling was limited to accessible areas and did not include areas covered by buildings, which account for approximately 30% of the Zone 1 area. Additional onsite soil investigations will be required following building demolition to inform the development and remediation planning process.
– While the future use of Zone 1 had not been established at the time of reporting, human use will be the primary purpose rather than ecological values.

Outcomes for Zone 2 (Roadway, Utilities Corridor and Reserve)

The HHERA was undertaken for Zone 2, demonstrated that exposure to PFAS-contaminated soil in Zone 2 is limited and represents a low risk to people and ecological receptors accessing the area.

The planning for the management of the PFAS-impacted soils in Zone 2 should focus on other factors, including stakeholder perceptions around the presence of elevated PFAS levels in publicly accessible land, the role of this area as an ongoing source of PFAS to the surrounding environment and the requirement for PFAS-impacted soil to be managed appropriately during future intrusive work.

Outcomes for Zone 3 (Christie Creek)

The key outcomes of the HHERA was undertaken for Zone 3 can be summarised as follows:

- The levels of PFAS in Christie Creek pose low risks to human users of the area.
- Direct exposure to PFAS represents a low risk to aquatic organisms inhabiting the creek.
- A clear indication of a measurable impact of the site on PFAS concentrations in Christie Creek surface water is not apparent in the dataset collected to date.
- It is likely that some bioaccumulation of PFAS occurs in lower trophic level organisms inhabiting Christie Creek, both upstream and downstream of the site. The weight of available evidence does not suggest that there are likely to be measurable adverse effects on higher trophic-level organisms.
- Future development works that reduce the areas of exposed surface soil in Zone 1 and Zone 2 will also reduce the migration of PFAS via stormwater runoff.

Several data gaps and uncertainties associated with the HHERA have been identified and are summarised in Section 3.3.2 and Section 4.4.

This Report is subject to and must be read in conjunction with, the limitations set out in Section 1.6 and the assumptions and qualifications contained throughout the Report.

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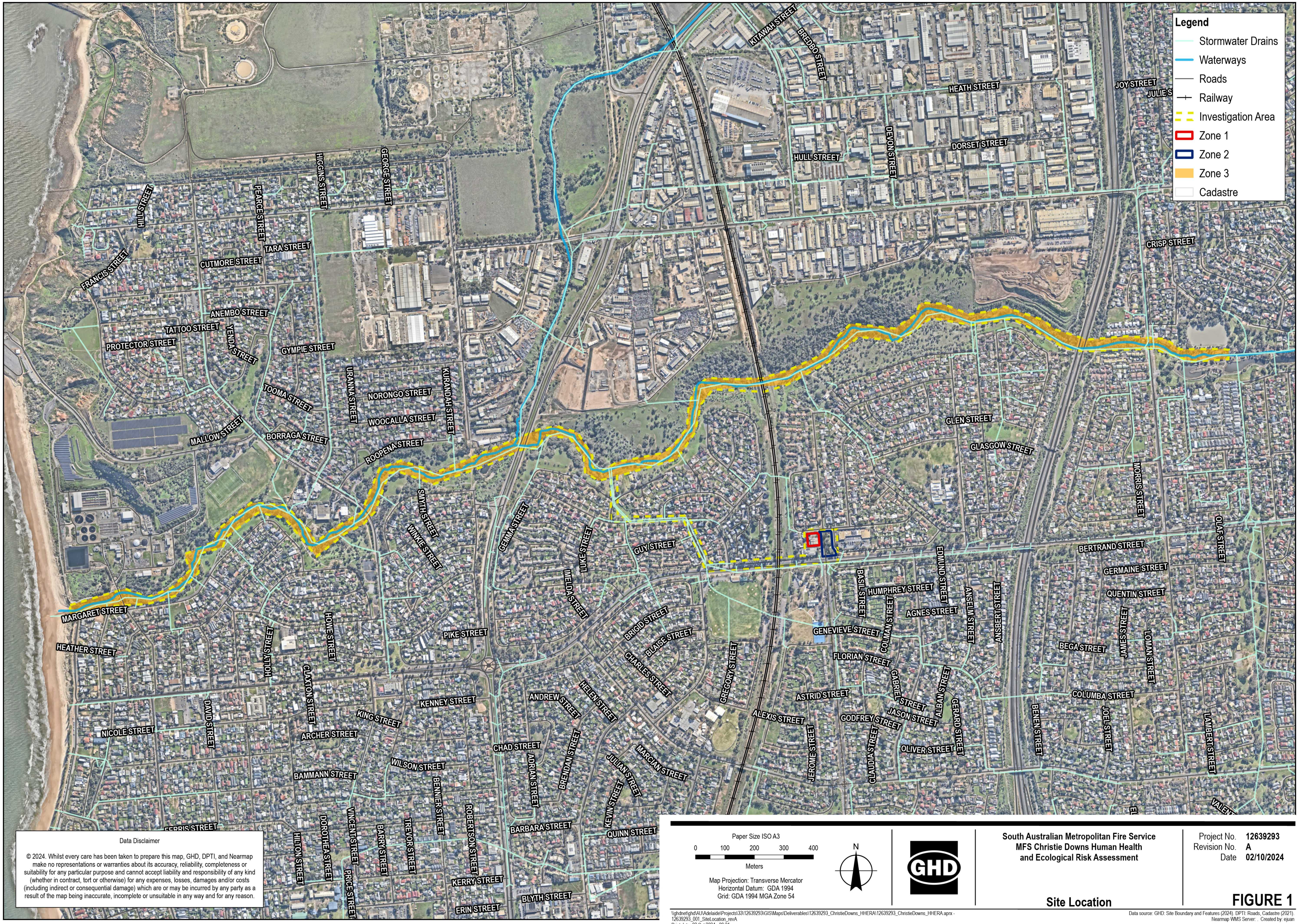
Appendices

Appendix A

Figures



Data Disclaimer

Paper Size ISO A3

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Meters

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

GHD

South Australian Metropolitan Fire Service
MFS Christie Downs Human Health and Ecological Risk Assessment

Project No. 12639293
Revision No. A
Date 02/10/2024

Site Location

FIGURE 1

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Data source: GHD: Site Boundary and Features (2024); DPTI: Roads, Cadastre (2021); Nearmap WMS Server. Created by: ejuan

Data Disclaimer

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

GHD

South Australian Metropolitan Fire Service
MFS Christie Downs Human Health and Ecological Risk Assessment

Project No. **12639293**
Revision No. **A**
Date **01/10/2024**

Site Layout

FIGURE 2

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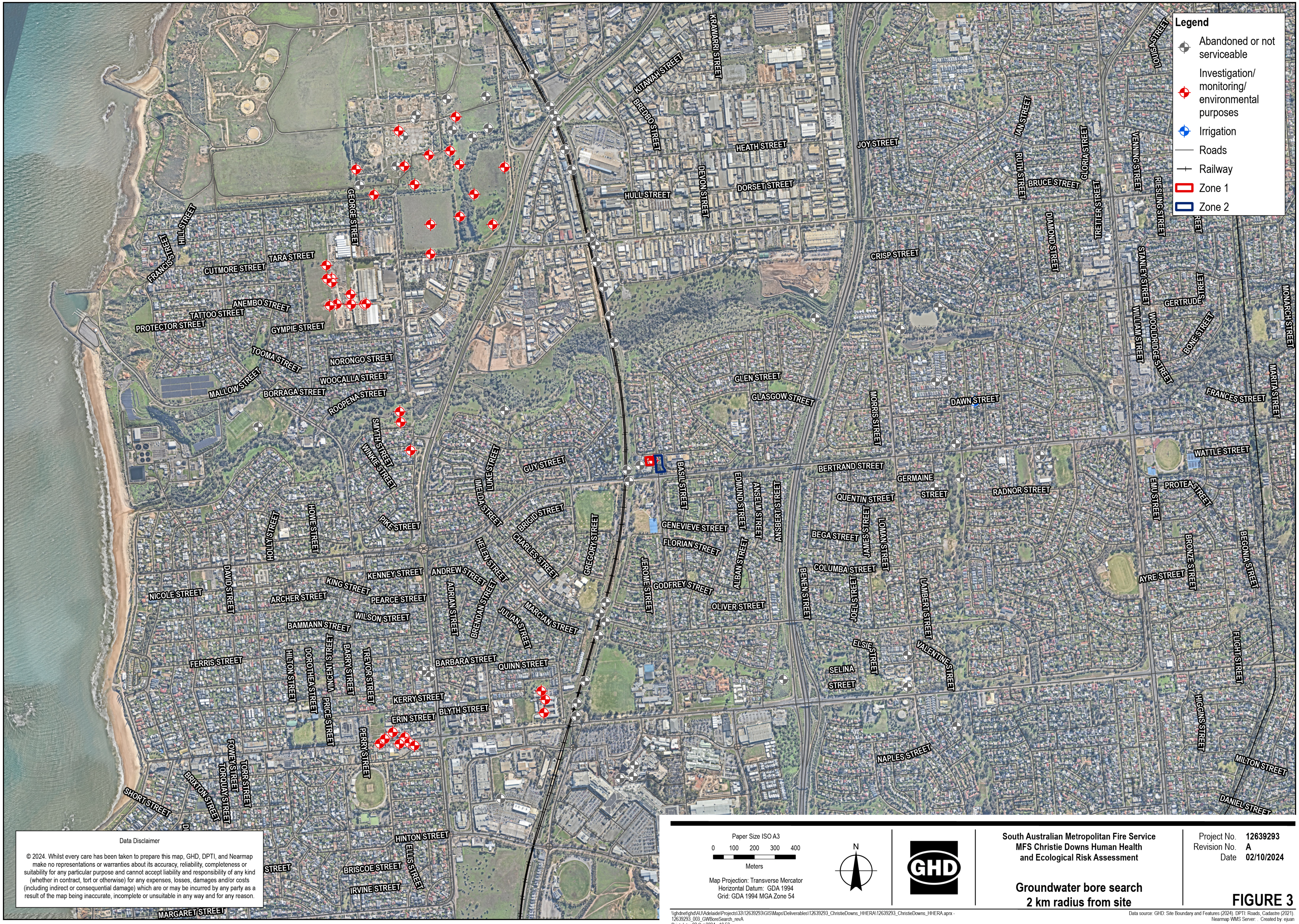

Data Disclaimer

Paper Size ISO A3

0 100 200 300 400

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

GHD

South Australian Metropolitan Fire Service
MFS Christie Downs Human Health and Ecological Risk Assessment

Groundwater bore search
2 km radius from site

Project No. **12639293**
Revision No. **A**
Date **02/10/2024**

FIGURE 3

\\ghdnet\ghd\AU\Adelaide\Projects\33\12639293\GIS\Maps\Deliverables\12639293_ChristieDowns_HHERA\12639293_ChristieDowns_HHERA.aprx - 12639293_003_GWBoreSearch_revA
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Meters
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

South Australian Metropolitan Fire Service
Christie Downs
Human health and Ecological Risk Assessment

Project No. 12639293
Revision No. C
Date 29/08/2024

Christie Downs Soil Sampling Locations

FIGURE 4

\\ghdnet\ghd\AU\Adelaide\Projects\33\12639293\GIS\Maps\Deliverables\12639293_ChristieDownsDSI.aprx
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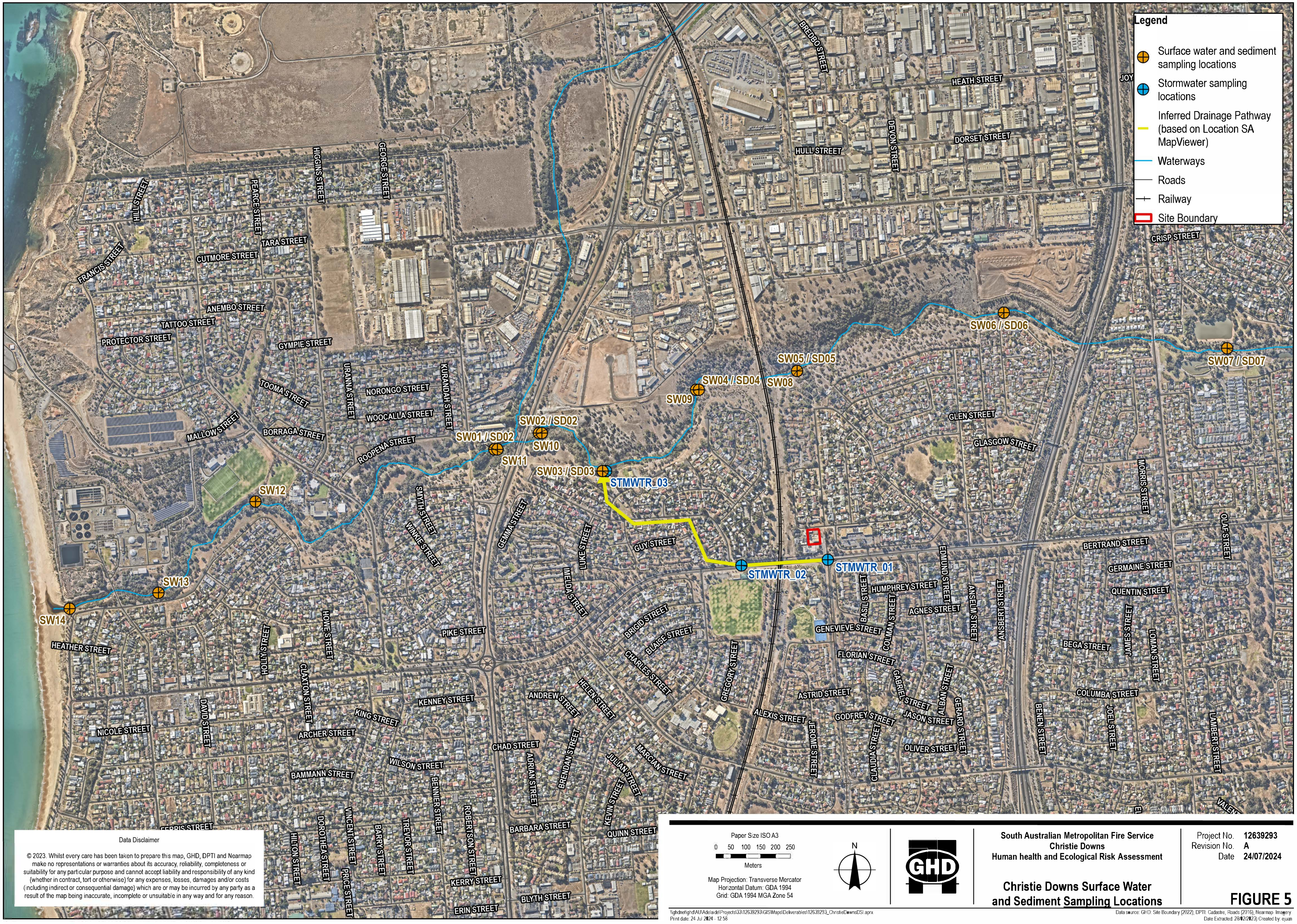
Date Extracted: 28/02/2023) Created by: ejuan



South Australian Metropolitan Fire Service
Christie Downs
Human health and Ecological Risk Assessment

Project No. 12639293
Revision No. A
Date 24/07/2024

Christie Downs Surface Water and Sediment Sampling Locations

FIGURE 5

\\ghdnet\ghd\AU\Adelaide\Projects\33\12639293\GIS\Maps\Deliverables\12639293_ChristieDownsDSI.aprx
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Data source: GHD: Site Boundary (2022); DPTI: Cadastre, Roads (2016), Nearmap Imagery Date Extracted: 28/02/2023) Created by: ejuan

Data Disclaimer

Appendix B

Consolidated analytical dataset

Location	Depth	Date	Field ID	Zone	Lab Report Number	PFAS - Perfluoroalkyl Sulfonic Acids								PFAS - Perfluoroalkyl Carboxylic Acids										
						Perfluorobutane sulfonic acid (PFBS)	Perfluorodecanesulfonic acid (PFDS)	Perfluorononane sulfonate (PFNS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluoropropanesulfonic acid (PFPrS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)	Perfluorobutanoic acid (PFBA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoDA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorooctanoic acid (PFOA)	Perfluoropentanoic acid (PFPeA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnDA)
						mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL						0.0002	0.0002	0.005	0.0002	0.0002	0.005	0.0002	0.0002	0.001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0002	0.0002
PFAS NEMP 2.0 2020 Residential with garden/accessible soil (HIL A)										0.01			0.01							0.1				
PFAS NEMP 2.0 2020 Residential w/ min opportunities for soil access (HIL B)										**2**			**2**							**20**				
PFAS NEMP 2.0 2020 Public open space (HIL C)										1			1							10				
PFAS NEMP 2.0 2020 Industrial/ commercial (HIL D)										*20*			*20*							*50*				
Zone 1 - The site																								
BH01	0 - 0.13	19 Jul 2023	BH01_0-0.13	1	1010934	<0.005	<0.005	<0.005	<0.005	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	3.4 - 3.5	19 Jul 2023	BH01_3.4-3.5	1	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH02	0.35 - 0.45	19 Jul 2023	BH02_0.35-0.45	1	1010934	<0.005	<0.005	0.025[#2]	<0.005	3.6[#2]	<0.005	<0.005	0.078[#2]	<0.005	0.012	0.0076[#2]	0.0063[#2]	0.015	0.0054	0.024[#2]	<0.005	<0.005	0.072[#2]	0.37[#2]
	2.7 - 2.8	19 Jul 2023	BH02_2.7-2.8	1	1010934	0.013[#2]	<0.005	<0.005	<0.005	<0.005	0.0059	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0064	0.091[#2]	<0.005	<0.005	<0.005	<0.005	<0.005
BH04	0.4 - 0.5	20 Jul 2023	BH04_0.4-0.5	1	1010934	<0.005	<0.005	<0.005	<0.005	0.46[#2]	<0.005	<0.005	0.016[#2]	<0.005	0.013	<0.005	<0.005	<0.005	0.0056	0.0079[#2]	<0.005	<0.005	0.016[#2]	0.21[#2]
	2.1 - 2.2	20 Jul 2023	BH04_2.1-2.2	1	1010934	<0.005	<0.005	<0.005	<0.005	0.029[#2]	<0.005	<0.005	0.019[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	0.03[#2]	<0.005	<0.005	<0.005	<0.005	<0.005
BH05	0	20 Jul 2023	BH05_CONCRETE	1	1010934	0.012[#2]	<0.005	<0.005	0.013[#2]	0.23[#2]	<0.005	0.015[#2]	0.15[#2]	<0.005	<0.005	<0.005	0.0061[#2]	0.037	<0.005	0.017[#2]	<0.005	<0.005	<0.005	<0.005
	0.12 - 0.2	20 Jul 2023	BH05_0.12-0.2	1	1010934	<0.005	<0.005	<0.005	<0.005	0.0099[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	1.8 - 1.9	20 Jul 2023	BH05_1.8-1.9	1	1010934	0.0052	<0.005	<0.005	<0.005	<0.005	<0.005	0.0053	0.0079[#2]	<0.005	<0.005	<0.005	<0.005	0.0058	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH06	0	20 Jul 2023	BH06_CONCRETE	1	1010934	0.032[#2]	<0.005	<0.005	<0.005	0.024[#2]	0.0079	0.033[#2]	0.11[#2]	<0.005	<0.005	<0.005	0.0095[#2]	0.076	<0.005	0.0079[#2]	0.012	<0.005	<0.005	<0.005
	0.15 - 0.35	20 Jul 2023	BH06_0.15-0.35	1	1010934	<0.005	<0.005	<0.005	<0.005	0.13[#2]	<0.005	<0.005	0.015[#2]	<0.005	<0.005	<0.005	<0.005	0.0060	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
			FD03	1	1010934	<0.005	<0.005	<0.005	<0.005	0.094[#2]	<0.005	<0.005	0.011[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
			FS03	1	EM2313591	0.0022	0.0003	-	0.0019	0.114	-	0.0031	0.0149	<0.001	<0.0002	<0.0002	0.0006	0.0068	0.0005	0.0021	0.0007	<0.0005	0.0002	0.0005
	2.4 - 2.5	20 Jul 2023	BH06_2.4-2.5	1	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH10	0.12 - 0.3	21 Jul 2023	BH10_0.12-0.3	1	1010934	<0.005	<0.005	<0.005	<0.005	0.054[#2]	<0.005	<0.005	0.0093[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	0.024[#2]	<0.005	<0.005	<0.005	<0.005	<0.005
	1 - 1.1	21 Jul 2023	BH10_1.0-1.1	1	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH11	0.12 - 0.22	21 Jul 2023	BH11_0.12-0.22	1	1010934	<0.005	<0.005	<0.005	<0.005	0.0080[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	1.5 - 1.6	21 Jul 2023	BH11_1.5-1.6	1	1010934	<0.005	<0.005	<0.005	<0.005	0.064[#2]	<0.005	<0.005	0.054[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH12	0 - 0.1	10 Apr 2024	BH12_0.0-0.1	1	1088156	<0.005	<0.005	<0.005	<0.005	0.029[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0053	<0.005
	0.05 - 0.15	21 Jul 2023	MW01_0.05-0.15	1	1010934	<0.005	<0.005	<0.005	<0.005	<0.005[#2]	<0.005	<0.005	<0.005[#2]	<0.005	<0.005	<0.005	<0.005	<0.005[#2]	<0.005	<0.005[#2]	<0.005	<0.005	<0.005	<0.005
	0.4 - 0.5	10 Apr 2024	BH12_0.4-0.5	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0070[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	2 - 2.1	21 Jul 2023	MW01_2.0-2.1	1	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	4.5 - 5	04 Sep 2023	MW01_4.5-5.0	1	1023122	<0.005	<0.005	<0.005	<0.005	<0.005[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	10	04 Sep 2023	MW01_10.0	1	1023122	<0.005	<0.005	<0.005	<0.005	<0.005[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	15	04 Sep 2023	MW01_15.0	1	1023122	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	20	04 Sep 2023	MW01_20.0	1	1023122	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH15		10 Apr 2024	QC02	1	1088156	0.0097[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	0.02[#2]	0.31[#2]	<0.005	<0.005	<0.005	0.012[#2]	0.025	<0.005	0.028[#2]	<0.005	<0.005	<0.005	<0.005
			QC02a	1	EM2406055	0.0106	<0.0002	-	0.0018	0.0016	-	0.0202	0.256	0.001	<0.0002	<0.0002	0.0110	0.0260	<0.0002	0.0201	0.0031	<0.0005	<0.0002	<0.0002
	0.4 - 0.5	10 Apr 2024	BH15_0.4-0.5	1	1088156	0.0062	<0.005	<0.005	<0.005	<0.005	<0.005	0.013[#2]	0.22[#2]	<0.005	<0.005	<0.005	0.0085[#2]	0.016	<0.005	0.022[#2]	<0.005	<0.005	<0.005	<0.005
	1 - 1.1	10 Apr 2024	BH15_1.0-1.1	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH16	0.4 - 0.5	10 Apr 2024	BH16_0.4-0.5	1	1088156	<0.005	<0.005	<0.005	<0.005	0.081[#2]	<0.005	<0.005	0.058[#2]	<0.005	0.0083[#2]	<0.005	0.018[#2]	0.0076	0.033[#2]	0.027[#2]	<0.005	<0.005	0.037	0.28[#2]
	1 - 1.1	10 Apr 2024	BH16_1.0-1.1	1	1088156	<0.005	<0.005	<0.005	<0.005	0.081[#2]	<0.005	<0.005	0.0074[#2]	<0.005	0.0063[#2]	<0.005	<0.005	<0.005	0.069[#2]	<0.005	<0.005	<0.005	<0.005	0.06[#2]
BH20	0 - 0.1	10 Apr 2024	BH20_0.0-0.1	1	1088156	<0.005	<0.005	<0.005	<0.005	0.0094[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	0.022[#2]
	0.4 - 0.5	10 Apr 2024	BH20_0.4-0.5	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01[#2]	<0.005	<0.005	<0.005	<0.005	<0.005
BH21		10 Apr 2024	QC05	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012[#2]	<0.005	0.023[#2]	<0.005	<0.005	<0.005	<0.005	<0.005
			QC05a	1	EM2406055	<0.0002	<0.0002	-	<0.0002	<0.0002	-	<0.0002	0.0005	<0.001	<0.0002	<0.0002	0.0065	0.0013	0.0095	0.0012	0.0007	<0.0005	<0.0002	0.0006
	0 - 0.1	10 Apr 2024	BH21_0.0-0.1	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	0.4 - 0.5	10 Apr 2024	BH21_0.4-0.5	1	1088156	<0.005	<0.005	<0.005	<0.005	0.057[#2]	<0.005	<0.005	0.0069[#2]	<0.005	0.027[#2]	<0.005	<0.005	<0.005	0.33[#2]	0.0057	<0.005	<0.005	0.047	0.34[#2]
	1.5 - 1.6	10 Apr 2024	BH21_1.5-1.6	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.015[#2]	<0.005	0.022[#2]	<0.005	<0.005	<0.005	<0.005	<0.005
BH22	0.4 - 0.5	10 Apr 2024	BH22_0.4-0.5	1	1088156	0.0080[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	0.0067[#2]	0.016[#2]	<0.005	<0.005	<0.005	0.015[#2]	0.014	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	1.5 - 1.6	10 Apr 2024	BH22_1.5-1.6	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH23	0.4 - 0.5	10 Apr 2024	BH23_0.4-0.5	1	1088156	<0.005	<0.005	<0.005	<0.005	0.015[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.017[#2]	<0.005	<0.005	<0.005	<0.005	<0.005
	1.5 - 1.6	10 Apr 2024	BH23_1.5-1.6	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH24		10 Apr 2024	QC07	1	1088156	<0.005	<0.005	<0.005	<0.005	0.017[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0059[#2]
			QC07a	1	EM2406055	<0.0002	0.0004	-	<0.0002	0.0077	-	<0.0002	<0.0002	<0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	<0.0002	0.0032
	0.4 - 0.5	10 Apr 2024	BH24_0.4-0.5	1	1088156	<0.005	<0.005	<0.005	<0.005	0.0082	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	1.5 - 1.6	10 Apr 2024	BH24_1.5-1.6	1	1088156	<0.005	<0.005	<0.005	0.0098[#2]	0.71[#2]	<0.005	<0.005	0.012[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	0.057[#2]	<0.005	<0.005	<0.005	<0.005	<0.005
BH25	1.5 - 1.6	10 Apr 2024	BH25_1.5-1.6	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	1.9 - 2	10 Apr 2024	BH25_1.9-2.0	1	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH26	0 - 0.1	11 Apr 2024	BH26_0.0-0.1	1	1088156	<0.005	<0.005	<0.005	<0.005	0.13[#2]	<0.005	<0.005	0.0067[#2]	<0.005	0.012	0.017[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.17	0.055[#2]
	0.4 - 0.5	11 Apr 2024	BH26_0.4-0.5	1	1088156	<0.005	<0.005	<0.005	<0.005	1.6[#2]	<0.005	<0.005	0.025[#2]	<0.005	0.027	<0.005	0.0081[#2]	0.011	0.0070[#2]	0.012[#2]	0.0073	<0.005	0.017	0.62[#2]
	1 - 1.1	09 Jul 2024	BH26_1.0-1.1	1	1117313	<0.005	<0.005	<0.005	0.0063[#2]	0.4[#2]	<0.005	<0.005	0.024[#2]	<0.005	0.034	<0.005	0.0088	0.0067	0.02	0.015[#2]	<0.005	<0.005	<0.005	0.39
BH27	0 - 0.1	11 Apr 2024	BH27_0.0-0.1	1	1088156	<0.005	0.012[#2]	0.011[#2]	<0.005	0.56[#2]	<0.005	<0.005	0.011[#2]	<0.005	0.0090	0.0086[#2]	<0.005	<0.005	0.0058[#2]	0.0083[#2]	<0.005	<0.005	0.05	0.041[#2]
	0.4 - 0.5	11 Apr 2024	BH27_0.4-0.5	1	1088156	<0.005	0.0052	0.045[#2]	<0.005	3.8[#2]	<0.005	<0.005	0.029[#2]	<0.005	<0.005	<0.005	0.0083[#2]	0.0050	0.022[#2]	0.018[#2]	<0.005	<0.005	0.0088	0.0085[#2]
	1 - 1.1	09 Jul 2024	BH27_1.0-1.1	1	1117313	<0.005	<0.005	<0.005	0.066	0.8	<0.005	<0.005	0.1	<0.005	<0.005	<0.005	<0.005	0.0068[#2]	0.018	0.0079[#2]	<0.005	<0.005	<0.005	0.0053
MW02	0.12 - 0.32	21 Jul 2023	FD04	1	1010934	<0.005	<0.005	<0.005	<0.005	0.057[#2]	<0.005	<0.005	0.0079[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
			FS04	1	EM2313591	<0.0002	0.0006	-	0.0004	0.0506	-	0.0002	0.0080	<0.001	0.0002	<0.0002	<0.0002	0.0023	0.0019	0.0006	<0.0002	<0.0005	0.0013	0.0036
			MW02_0.12-0.32	1	1010934	<0.005	<0.005	<0.005	<0.005	0.054[#2]	<0.005	<0.005	0.0079[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	2.2 - 2.3	21 Jul 2023	MW02_2.2-2.3	1	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
MW03	0.12 - 0.22	21 Jul 2023	MW03_0.12-0.22	1	1010934	<0.005	<0.005	<0.005	<0.005	0.073[#2]	<0.005	<0.005	0.012[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	0.06[#2]	<0.005	<0.005	<0.005	0.021[#2]	0.033[#2]
	3.4 - 3.5	21 Jul 2023	MW03_3.4-3.5	1	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
SS01	0 - 0.1	21 Jul 2023	FD05	1	1010934	<0.005	<0.005	<0.005	<0.005	0.07[#2]	<0.005	<0.005	0.011[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	0.0051	<0.005	<0.005	<0.005	0.058[#2]	0.059[#2]
			FS05	1	EM2313591	<0.0002	0.0008	-	<0.0002	0.0386	-	0.0003	0.0047	<0.001	0.0011	0.0020	0.0002	0.0004	0.0025	0.0006	0.0006	<0.0005	0.0447	0.0329
			SS01	1	1010934	<0.005	<0.005	<0.005	<0.005	0.066[#2]	<0.005	<0.005	0.0068	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.067[#2]	0.054[#2]
SS02	0 - 0.1	21 Jul 2023	SS02	1	1010934	<0.005	<0.005	<0.005	<0.005	0.0064[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.013[#2]	0.0076[#2]
SS03	0 - 0.1	04 Sep 2023	SS03	1	1023122	<0.005	<0.005	<0.005	<0.005	0.25[#2]	<0.005	<0.005	0.0053[#2]	<0.005	0.014	0.0084	<0.005	<0.005	0.0068	<0.005	<0.005	<0.005	0.21	0.079
SS04	0 - 0.1	04 Sep 2023	SS04	1	1023122	<0.005	<0.005	<0.005	<0.005	0.03[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005[#2]	<0.005	<0.005	<0.005	0.1	0.038
SS05	0 - 0.1	04 Sep 2023	SS05	1	1023122	<0.005	<0.005	<0.005	<0.005	0.091[#2]	<0.005	<0.005	<0.005[#2]	<0.005	0.011	0.0098	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.33	0.049
SS06	0 - 0.1	04 Sep 2023	SS06	1	1023122	<0.005	<0.005	<0.005	<0.005	<0.005[#2]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0063
SS14	0 - 0.1	09 Jul 2024	SS14	1	1117313	<0.005	<0.005	<0.005	<0.005	0.022[#1]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.032	0.028
SS15	0 - 0.1	09 Jul 2024	SS15	1	1117313	<0.005	<0.005	0.0096	<0.005	0.74[#1]	<0.005	<0.005	0.066	<0.005	0.016	0.0055	<0.005	0.0075[#1]	0.068	<0.005	<0.005	<0.005	0.19	0.45

						PFAS - Perfluoroalkyl Sulfonic Acids								PFAS - Perfluoroalkyl Carboxylic Acids										
						Perfluorobutane sulfonic acid (PFBS)	Perfluorodecanesulfonic acid (PFDS)	Perfluorononane sulfonate (PFNS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluoropropanesulfonic acid (PFPrS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)	Perfluorobutanoic acid (PFBA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoDA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorooctanoic acid (PFOA)	Perfluoropentanoic acid (PFPeA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnDA)
						mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL						0.0002	0.0002	0.005	0.0002	0.0002	0.005	0.0002	0.0002	0.001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0002	0.0002
PFAS NEMP 2.0 2020 Residential with garden/accessible soil (HIL A)										0.01			0.01							0.1				
PFAS NEMP 2.0 2020 Residential w/ min opportunities for soil access (HIL B)										2			2							20				
PFAS NEMP 2.0 2020 Public open space (HIL C)										1			1							10				
PFAS NEMP 2.0 2020 Industrial/ commercial (HIL D)										*20*			*20*							*50*				
Location	**Depth**	**Date**	**Field ID**	**Zone**	**Lab Report Number**																			
Zone 2 - Holman Rd and the reserve area																								
BH03	0	20 Jul 2023	BH03_BITUMEN	2	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	0.04 - 0.14	20 Jul 2023	BH03_0.04-0.14	2	1010934	<0.005	<0.005	<0.005	<0.005	0.0100	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	2.1 - 2.2	20 Jul 2023	BH03_2.1-2.2	2	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH07	0	20 Jul 2023	BH07_BITUMEN	2	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
			FD01	2	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
			FS01	2	EM2313591	<0.0002	<0.0002	-	<0.0002	0.0004	-	<0.0002	<0.0002	<0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	<0.0002	<0.0002
	1 - 1.1	20 Jul 2023	BH07_1.0-1.1	2	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	2.6 - 2.7	20 Jul 2023	BH07_2.6-2.7	2	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH08	0	20 Jul 2023	BH08_BITUMEN	2	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	0.05 - 0.15	20 Jul 2023	BH08_0.05-0.15	2	1010934	<0.005	<0.005	<0.005	<0.005	0.0064#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
			FD02	2	1010934	<0.005	<0.005	<0.005	<0.005	0.01#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
			FS02	2	EM2313591	<0.0002	<0.0002	-	<0.0002	0.0113	-	<0.0002	0.0016	<0.001	<0.0002	<0.0002	<0.0002	0.0016	0.0007	<0.0002	0.0009	<0.0005	<0.0002	0.0019
	0.35 - 0.45	20 Jul 2023	BH08_0.35-0.45	2	1010934	<0.005	<0.005	<0.005	<0.005	0.044#2	<0.005	<0.005	0.0064#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0085
	3.2 - 3.3	20 Jul 2023	BH08_3.2-3.3	2	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH09	0 - 0.15	20 Jul 2023	BH09_0-0.15	2	1010934	<0.005	<0.005	0.0061#2	<0.005	0.35#2	<0.005	<0.005	<0.005	<0.005	0.027	0.018#2	<0.005	<0.005	<0.005	<0.005	<0.005	0.0050	0.14	0.077
	3.4 - 3.5	20 Jul 2023	BH09_3.4-3.5	2	1010934	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH13	0 - 0.1	10 Apr 2024	BH13_0.0-0.1	2	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0076#2
	0.4 - 0.5	10 Apr 2024	BH13_0.4-0.5	2	1088156	<0.005	<0.005	<0.005	<0.005	0.011#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0070	<0.005	<0.005	<0.005	<0.005	<0.005
BH14	0 - 0.1	10 Apr 2024	BH14_0.0-0.1	2	1088156	<0.005	<0.005	<0.005	<0.005	0.036#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0051	0.017#2
	0.4 - 0.5	10 Apr 2024	BH14_0.4-0.5	2	1088156	<0.005	<0.005	<0.005	<0.005	0.03#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.016#2	<0.005	<0.005	<0.005	<0.005	0.0062#2
BH17		10 Apr 2024	QC03	2	1088156	<0.005	<0.005	<0.005	<0.005	0.13#2	<0.005	<0.005	0.012	<0.005	<0.005	<0.005	<0.005	<0.005	0.14#2	0.0054	<0.005	<0.005	<0.005	<0.005
			QC03a	2	EM2406055	0.0007	<0.0002	-	0.0006	0.101	-	0.0006	0.0100	<0.001	0.0007	<0.0002	0.0029	0.0024	0.159	0.0036	0.0015	<0.0005	<0.0002	0.0007
	1 - 1.1	10 Apr 2024	BH17_1.0-1.1	2	1088156	<0.005	<0.005	<0.005	<0.005	0.18#2	<0.005	<0.005	0.0069#2	<0.005	0.0070#2	<0.005	<0.005	<0.005	0.039#2	<0.005	<0.005	<0.005	<0.005	0.018#2
	1.5 - 1.6	10 Apr 2024	BH17_1.5-1.6	2	1088156	<0.005	<0.005	<0.005	<0.005	0.11#2	<0.005	<0.005	0.01#2	<0.005	<0.005	<0.005	<0.005	<0.005	0.12#2	<0.005	<0.005	<0.005	<0.005	<0.005
BH18	0.4 - 0.5	10 Apr 2024	BH18_0.4-0.5	2	1088156	<0.005	<0.005	<0.005	<0.005	0.85#2	<0.005	<0.005	0.016#2	<0.005	0.0064#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.2#2
BH19	0 - 0.1	10 Apr 2024	BH19_0.0-0.1	2	1088156	<0.005	0.014#2	0.017#2	<0.005	0.97#2	<0.005	<0.005	0.022#2	<0.005	0.0095	0.0056#2	<0.005	0.0062	<0.005	0.0060#2	<0.005	<0.005	0.034	0.11
	0.4 - 0.5	10 Apr 2024	BH19_0.4-0.5	2	1088156	<0.005	<0.005	<0.005	0.036#2	6.6#2	<0.005	<0.005	0.091#2	<0.005	<0.005	<0.005	<0.005	0.0065	0.1#2	0.019#2	<0.005	<0.005	<0.005	0.0056#2
	1 - 1.1	09 Jul 2024	BH19_1.0-1.1	2	1117313	<0.005	<0.005	<0.005	0.0057	0.092#2	<0.005	0.0056	0.23#2	<0.005	<0.005	<0.005	0.014	0.012	0.15	0.047#2	0.0095	<0.005	<0.005	0.0086
BH28	0.4 - 0.5	11 Apr 2024	BH28_0.4-0.5	2	1088156	<0.005	<0.005	<0.005	0.01	0.83#2	<0.005	<0.005#2	0.1#2	<0.005	<0.005	<0.005	0.0052	0.016	0.012	0.012	0.0061	<0.005	<0.005	0.0074
BH29	0.4 - 0.5	11 Apr 2024	BH29_0.4-0.5	2	1088156	<0.005	<0.005	<0.005	0.0058	0.94#2	<0.005	<0.005#2	0.081#2	<0.005	0.0069	0.0081	<0.005	0.022	0.038	0.0074	<0.005	<0.005	0.16	0.13
	1 - 1.1	09 Jul 2024	BH29_1.0-1.1	2	1117313	<0.005	<0.005	0.0054	0.0072	0.43	<0.005	<0.005	0.038	<0.005	<0.005	<0.005	<0.005	0.0058#2	0.035	<0.005	<0.005	<0.005	0.025	0.098
BH30	0 - 0.1	13 Aug 2024	QC1A	2	EM2414005	<0.0002	0.0018	-	0.0005	0.287	-	<0.0002	0.0014	<0.001	0.0092	0.0022	0.0002	0.0004	0.0254	0.0005	0.0004	<0.0005	0.0674	0.118
		13 Aug 2024	BH30_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.34#2	<0.005	<0.005	<0.005	<0.005	0.011#2	<0.005	<0.005	<0.005	0.026#2	<0.005	<0.005	<0.005	0.047#2	0.13#2
			QC1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.27#2	<0.005	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	0.025	<0.005	<0.005	<0.005	0.036	0.16
BH31	0 - 0.1	13 Aug 2024	BH31_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.025#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH32	0 - 0.1	13 Aug 2024	BH32_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.12#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH33	0 - 0.1	13 Aug 2024	BH33_0.0-0.1	2	1129117	<0.005	0.015#2	0.035#2	<0.005	1.3#2	<0.005	<0.005	0.01#2	<0.005	0.01#2	<0.005	<0.005	<0.005	0.0067#2	<0.005	<0.005	<0.005	0.032#2	0.063#2
	0.4 - 0.5	13 Aug 2024	BH33_0.4-0.5	2	1132369	<0.005	0.012#2	0.021#2	<0.005	1.7#2	<0.005	<0.005	0.025#2	<0.005	<0.005	<0.005	<0.005	<0.005	0.022#2	0.0058	<0.005	<0.005	0.0077	0.02
	0.9 - 1	13 Aug 2024	BH33_0.9-1.0	2	1134925	0.028	<0.005	<0.005	0.05#2	0.64#2	0.012	0.028#2	0.76#2	<0.005	<0.005	<0.005	0.0084#2	0.09#2	0.029	0.095#2	0.017	<0.005	<0.005	<0.005
BH34	0 - 0.1	13 Aug 2024	BH34_0.0-0.1	2	1129117	<0.005	0.017#2	0.064#2	<0.005	1.4#2	<0.005	<0.005	0.014#2	<0.005	0.017#2	<0.005	<0.005	<0.005	0.0090#2	<0.005	<0.005	<0.005	0.03#2	0.11#2
	0.4 - 0.5	13 Aug 2024	BH34_0.4-0.5	2	1132369	<0.005	<0.005	0.011#2	0.043#2	2.4#2	<0.005	<0.005	0.083#2	<0.005	<0.005	<0.005	<0.005	<0.005	0.15#2	0.014#2	<0.005	<0.005	0.0088	0.026
	0.9 - 1	13 Aug 2024	BH34_0.9-1.0	2	1134925	0.045	<0.005	<0.005	0.078#2	0.28#2	0.017	0.11#2	1.4#2	0.0090	<0.005	<0.005	0.034#2	0.12#2	0.058	0.1#2	0.022	<0.005	<0.005	<0.005
BH35	0 - 0.1	13 Aug 2024	BH35_0.0-0.1	2	1129117	0.0085#2	0.015#2	0.066#2	0.041#2	7.6#2	0.0067	0.0052	0.083#2	<0.005	0.021#2	0.0052	<0.005	0.022	0.058#2	0.028#2	<0.005	<0.005	0.1#2	0.27#2
	0.4 - 0.5	13 Aug 2024	BH35_0.4-0.5	2	1132369	0.02#2	<0.005	<0.005	0.17	8.8#2	0.01	0.027	1.1	0.0074	0.016	<0.005	0.011#2	0.062	0.75	0.16	0.0098	<0.005	0.042	0.12
BH36	0 - 0.1	13 Aug 2024	BH36_0.0-0.1	2	1129117	<0.005	0.0073#2	0.0092#2	<0.005	0.32#2	<0.005	<0.005	0.011#2	<0.005	0.0100	0.01#2	<0.005	<0.005	<0.005	0.0058	<0.005	<0.005	0.18#2	0.13#2
BH37	0 - 0.1	13 Aug 2024	BH37_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.1#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0063#2	0.016#2
BH38	0 - 0.1	13 Aug 2024	BH38_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.061#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0063#2
BH39	0 - 0.1	13 Aug 2024	BH39_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.23#2	<0.005	<0.005	<0.005	<0.005	0.012#2	<0.005	<0.005	<0.005	0.075#2	0.0091#2	<0.005	<0.005	0.023#2	0.11#2
BH40	0 - 0.1	13 Aug 2024	BH40_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.09#2	<0.005	<0.005	<0.005	<0.005	0.0071	<0.005	<0.005	<0.005	0.25	<0.005	<0.005	<0.005	0.029	0.1
BH41	0.4 - 0.5	13 Aug 2024	SS10/BH41_0.4-0.5	2	1129117	<0.005	<0.005	<0.005	0.0085#2	0.19#2	<0.005	<0.005	0.14#2	<0.005	<0.005	<0.005	0.0085#2	0.0091	0.24	0.039#2	<0.005	<0.005	0.0055	0.028
BH42	0.4 - 0.5	13 Aug 2024	SS10/BH42_0.4-0.5	2	1129117	0.014#2	<0.005	0.0066#2	0.034#2	0.73#2	<0.005	0.02#2	0.44#2	<0.005	<0.005	<0.005	0.011#2	0.034	0.26#2	0.082#2	<0.005	<0.005	0.018#2	0.041#2
BH43	0 - 0.1	13 Aug 2024	BH43_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.0073#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH44	0 - 0.1	13 Aug 2024	BH44_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.01#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH45	0 - 0.1	13 Aug 2024	BH45_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.023#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH46	0 - 0.1	13 Aug 2024	BH46_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.0095#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BH47	0 - 0.1	13 Aug 2024	BH47_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.11#2	<0.005	<0.005	<0.005	<0.005	0.015	0.012	<0.005	<0.005	0.038	<0.005	<0.005	<0.005	0.19	0.81
BH48	0.2 - 0.3	13 Aug 2024	BH48_0.2-0.3	2	1129117	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.13	<0.005	<0.005	<0.005	<0.005	0.019
BH49	0 - 0.1	14 Aug 2024	QC3A	2	EM2414005	<0.0002	<0.0002	-	0.0003	0.0571	-	<0.0002	0.0014	<0.001	<0.0002	<0.0002	<0.0002	0.0002	0.0003	0.0004	<0.0002	<0.0005	0.0005	0.0007
		13 Aug 2024	BH49_0.0-0.1	2	1129117	<0.005	<0.005	<0.005	<0.005	0.063#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
			QC3	2	1129117	<0.005	<0.005	<0.005	<0.005	0.063#2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
SS07	0 - 0.1	09 Jul 2024	SS07	2	1117313	<0.005	<0.005	<0.005	<0.005	0.14#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.013#1
SS08	0 - 0.1	09 Jul 2024	SS08	2	1117313	<0.005	0.016#1	0.027#1	<0.005	0.42#1	<0.005	<0.005	0.014#1	<0.005	0.013	<0.005	<0.005	<0.005	0.012	<0.005	<0.005	<0.005	0.021	0.1#1
SS09	0 - 0.1	09 Jul 2024	SS09	2	1117313	<0.005	0.0089#1	0.0075#1	<0.005	0.31#1	<0.005	<0.005	0.0091#1	<0.005	0.018	0.011	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.13	0.34#1
SS10	0 - 0.1	09 Jul 2024	SS10	2	1117313	0.021#1	0.021	0.098	<0.015#1	11#1	0.026	0.017#1	0.16#1	0.012	0.0063	0.013	0.0078#1	0.046	<0.005	0.037#1	0.011	<0.005	0.2	0.23#1
SS11	0 - 0.1	09 Jul 2024	SS11	2	1117313	0.02#1	0.023	0.1	<0.015#1	11#1	0.024	0.016#1	0.15#1	0.012	0.0055	0.011	0.0074#1	0.043	<0.005	0.035#1	0.011	<0.005	0.17	0.21#1
SS12	0 - 0.1	09 Jul 2024	SS12	2	1117313	<0.005	<0.005	<0.005	<0.005	0.036#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
SS13	0 - 0.1	09 Jul 2024	SS13	2	1117313	<0.005	<0.005	<0.005	<0.005	0.095	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.015#1

Comments

#1 If the concentration of PFHxS > PFOS this guideline value needs to be adjusted accordingly. Please refer to Section 8.5.2.1 of the PFAS NEMP 2.0 guideline for further information
#2 Quantification of linear and branched isomers has been conducted as a single total response using the relative response factor for the corresponding linear/branched standard.

Environmental Standards

HEPA, Jan 2020, PFAS NEMP 2.0 2020 Residential with garden/accessible soil (HIL A)
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Residential w/ min opportunities for soil access (HIL B)
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Public open space (HIL C)
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Industrial/ commercial (HIL D)

						PFAS - Perfluoroalkyl Sulfonamide							PFAS - Fluorotelomer Sulfonic Acids				PFAS - Sums				Misc.	Inorganics	PFAS - Sums
						N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-Methyl perfluorooctane sulfonamidoethanol (MEFOSE)	Perfluorooctane sulfonamide (FOSA)	10:2 Fluorotelomer sulfonic acid (10:2 FTS)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer Sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	PFAS (Sum of Total)	PFAS (Sum of Total)(WA DER List)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of PFHxS and PFOS	% Moisture_	Moisture (%)	Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*
						mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	%	mg/kg
EQL						0.0005	0.0002	0.0005	0.0005	0.0002	0.0005	0.0002	0.0005	0.0005	0.0005	0.0005	0.0002	0.0002	0.005	0.0002	1	0.1	0.005
PFAS NEMP 2.0 2020 Residential with garden/accessible soil (HIL A)																				0.01#1			
PFAS NEMP 2.0 2020 Residential w/ min opportunities for soil access (HIL B)																				2#1			
PFAS NEMP 2.0 2020 Public open space (HIL C)																				1			
PFAS NEMP 2.0 2020 Industrial/ commercial (HIL D)																				*20*			
Location	**Depth**	**Date**	**Field ID**	**Zone**	**Lab Report Nur**																		
Zone 1 - The site																							
BH01	0 - 0.13	19 Jul 2023	BH01_0-0.13	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.013	0.013	0.013	5.0	-	0.013
	3.4 - 3.5	19 Jul 2023	BH01_3.4-3.5	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	10	-	<0.005
BH02	0.35 - 0.45	19 Jul 2023	BH02_0.35-0.45	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0081	<0.005	<0.01	0.033	4.2564	3.7563	3.624	3.678	16	-	3.702
	2.7 - 2.8	19 Jul 2023	BH02_2.7-2.8	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.1163	0.0194	<0.005	<0.005	7.6	-	<0.005
BH04	0.4 - 0.5	20 Jul 2023	BH04_0.4-0.5	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.011	<0.005	<0.01	0.029	0.7685	0.5129	0.4679	0.476	17	-	0.4839
	2.1 - 2.2	20 Jul 2023	BH04_2.1-2.2	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.078	0.048	0.029	0.048	7.5	-	0.048
BH05	0	20 Jul 2023	BH05_CONCRETE	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	0.024	<0.005	0.5041	0.4761	0.247	0.38	2.2	-	0.397
	0.12 - 0.2	20 Jul 2023	BH05_0.12-0.2	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0099	0.0099	3.5	-	0.0099
	1.8 - 1.9	20 Jul 2023	BH05_1.8-1.9	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.0189	<0.005	0.0079	9.2	-	0.0079
BH06	0	20 Jul 2023	BH06_CONCRETE	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.3123	0.2714	0.0319	0.134	2.2	-	0.1419
	0.15 - 0.35	20 Jul 2023	BH06_0.15-0.35	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.151	0.151	0.13	0.145	2.8	-	0.145
			FD03	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.105	0.105	0.094	0.105	2.3	-	0.105
			FS03	1	EM2313591	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.148	0.141	-	0.129	-	1.7	-
	2.4 - 2.5	20 Jul 2023	BH06_2.4-2.5	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	8.3	-	<0.005
BH10	0.12 - 0.3	21 Jul 2023	BH10_0.12-0.3	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0873	0.0633	0.054	0.0633	1.6	-	0.0633
	1 - 1.1	21 Jul 2023	BH10_1.0-1.1	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	11	-	<0.005
BH11	0.12 - 0.22	21 Jul 2023	BH11_0.12-0.22	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.008	0.008	4.3	-	0.008
	1.5 - 1.6	21 Jul 2023	BH11_1.5-1.6	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.118	0.118	0.064	0.118	13	-	0.118
BH12	0 - 0.1	10 Apr 2024	BH12_0.0-0.1	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.029	0.029	0.029	5.2	-	0.029
	0.05 - 0.15	21 Jul 2023	MW01_0.05-0.15	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<1	-	<0.005
	0.4 - 0.5	10 Apr 2024	BH12_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	0.007	8.8	-	0.007
	2 - 2.1	21 Jul 2023	MW01_2.0-2.1	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	8.1	-	<0.005
	4.5 - 5	04 Sep 2023	MW01_4.5-5.0	1	1023122	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	7.4	-	<0.005
	10	04 Sep 2023	MW01_10.0	1	1023122	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	7.9	-	<0.005
	15	04 Sep 2023	MW01_15.0	1	1023122	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	1.1	-	<0.005
	20	04 Sep 2023	MW01_20.0	1	1023122	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<1	-	<0.005
BH15		10 Apr 2024	QC02	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.4047	0.3847	0.028	0.31	12	-	0.338
			QC02a	1	EM2406055	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.355	0.329	-	0.258	-	10.1	-
	0.4 - 0.5	10 Apr 2024	BH15_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2857	0.2727	0.022	0.22	23	-	0.242
	1 - 1.1	10 Apr 2024	BH15_1.0-1.1	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	12	-	<0.005
BH16	0.4 - 0.5	10 Apr 2024	BH16_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	0.0093	0.5592	0.2009	0.108	0.139	9.9	-	0.166
	1 - 1.1	10 Apr 2024	BH16_1.0-1.1	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2237	0.0884	0.081	0.0884	10	-	0.0884
BH20	0 - 0.1	10 Apr 2024	BH20_0.0-0.1	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0094	0.0094	2.0	-	0.0094
	0.4 - 0.5	10 Apr 2024	BH20_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	9.4	-	<0.005
BH21		10 Apr 2024	QC05	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.012	<0.005	<0.005	14	-	<0.005
			QC05a	1	EM2406055	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.0203	0.0102	-	0.0005	-	12.0	-
	0 - 0.1	10 Apr 2024	BH21_0.0-0.1	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	2.2	-	<0.005
	0.4 - 0.5	10 Apr 2024	BH21_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.8136	0.0696	0.0627	0.0639	14	-	0.0696
	1.5 - 1.6	10 Apr 2024	BH21_1.5-1.6	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.015	<0.005	<0.005	14	-	<0.005
BH22	0.4 - 0.5	10 Apr 2024	BH22_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0597	0.053	<0.005	0.016	13	-	0.016
	1.5 - 1.6	10 Apr 2024	BH22_1.5-1.6	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	9.5	-	<0.005
BH23	0.4 - 0.5	10 Apr 2024	BH23_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.015	0.015	0.015	<1	-	0.015
	1.5 - 1.6	10 Apr 2024	BH23_1.5-1.6	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	11	-	<0.005
BH24		10 Apr 2024	QC07	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.017	0.017	0.017	3.2	-	0.017
			QC07a	1	EM2406055	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	0.0003	<0.0005	<0.0005	<0.0005	<0.0005	0.0116	0.0077	-	0.0077	-	3.1	-
	0.4 - 0.5	10 Apr 2024	BH24_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0082	0.0082	3.1	-	0.0082
	1.5 - 1.6	10 Apr 2024	BH24_1.5-1.6	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.7888	0.722	0.71	0.722	28	-	0.722
BH25	1.5 - 1.6	10 Apr 2024	BH25_1.5-1.6	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	14	-	<0.005
	1.9 - 2	10 Apr 2024	BH25_1.9-2.0	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	11	-	<0.005
BH26	0 - 0.1	11 Apr 2024	BH26_0.0-0.1	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.085	<0.005	<0.01	0.01	0.4857	0.1467	0.13	0.1367	5.5	-	0.1367
	0.4 - 0.5	11 Apr 2024	BH26_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.014	<0.005	0.019	0.042	2.4094	1.7244	1.612	1.625	9.1	-	1.637
	1 - 1.1	09 Jul 2024	BH26_1.0-1.1	1	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	0.015	0.064	0.9838	0.5335	0.415	0.424	13	-	0.439
BH27	0 - 0.1	11 Apr 2024	BH27_0.0-0.1	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0078	<0.005	<0.01	0.027	0.7515	0.6063	0.5683	0.571	3.4	-	0.5793
	0.4 - 0.5	11 Apr 2024	BH27_0.4-0.5	1	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	0.063	4.0128	3.9233	3.818	3.829	11	-	3.847
	1 - 1.1	09 Jul 2024	BH27_1.0-1.1	1	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.004	0.9147	0.8079	0.9	29	-	0.9079
MW02	0.12 - 0.32	21 Jul 2023	FD04	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0649	0.0649	0.057	0.0649	2.1	-	0.0649
			FS04	1	EM2313591	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.0697	0.0615	-	0.0586	-	2.5	-
			MW02_0.12-0.32	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0619	0.0619	0.054	0.0619	2.7	-	0.0619
	2.2 - 2.3	21 Jul 2023	MW02_2.2-2.3	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	10	-	<0.005
MW03	0.12 - 0.22	21 Jul 2023	MW03_0.12-0.22	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.199	0.085	0.073	0.085	3.9	-	0.085
	3.4 - 3.5	21 Jul 2023	MW03_3.4-3.5	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	12	-	<0.005
SS01	0 - 0.1	21 Jul 2023	FD05	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2031	0.081	0.07	0.081	29	-	0.081
			FS05	1	EM2313591	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.129	0.0451	-	0.0433	-	28.6	-
			SS01	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.1938	0.0728	0.066	0.0728	30	-	0.0728
SS02	0 - 0.1	21 Jul 2023	SS02	1	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0064	0.0064	11	-	0.0064
SS03	0 - 0.1	04 Sep 2023	SS03	1	1023122	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.01	<0.005	<0.01	<0.005	0.5835	0.2553	0.25	0.2553	18	-	0.2553
SS04	0 - 0.1	04 Sep 2023	SS04	1	1023122	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0073	<0.005	<0.01	<0.005	0.1753	0.03	0.03	0.03	6.7	-	0.03
SS05	0 - 0.1	04 Sep 2023	SS05	1	1023122	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.015	<0.005	<0.01	<0.005	0.5058	0.091	0.091	0.091	24	-	0.091
SS06	0 - 0.1	04 Sep 2023	SS06	1	1023122	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	3.7	-	<0.005
SS14	0 - 0.1	09 Jul 2024	SS14	1	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	0.0056	<0.005	<0.005	<0.005	<0.01	<0.005	0.0876	0.022	0.022	0.022	0.022	11	-
SS15	0 - 0.1	09 Jul 2024	SS15	1	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0099	<0.005	<0.01	<0.005	1.5625	0.8135	0.74	0.806	0.806	13	-

						PFAS - Perfluoroalkyl Sulfonamide							PFAS - Fluorotelomer Sulfonic Acids				PFAS - Sums				Misc.	Inorganics	PFAS - Sums
						N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-Methyl perfluorooctane sulfonamidoethanol (MEFOSE)	Perfluorooctane sulfonamide (FOSA)	10:2 Fluorotelomer sulfonic acid (10:2 FTS)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer Sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	PFAS (Sum of Total)	PFAS (Sum of Total)(WA DER List)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of PFHxS and PFOS	% Moisture_	Moisture (%)	Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*
						mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	%	mg/kg
EQL						0.0005	0.0002	0.0005	0.0005	0.0002	0.0005	0.0002	0.0005	0.0005	0.0005	0.0005	0.0002	0.0002	0.005	0.0002	1	0.1	0.005
PFAS NEMP 2.0 2020 Residential with garden/accessible soil (HIL A)																				0.01[#1]			
PFAS NEMP 2.0 2020 Residential w/ min opportunities for soil access (HIL B)																				2[#1]			
PFAS NEMP 2.0 2020 Public open space (HIL C)																				1			
PFAS NEMP 2.0 2020 Industrial/ commercial (HIL D)																				*20*			
Location	**Depth**	**Date**	**Field ID**	**Zone**	**Lab Report Nur**																		
Zone 2 - Holman Rd and the reserve area																							
BH03	0	20 Jul 2023	BH03_BITUMEN	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<1	-	<0.005
	0.04 - 0.14	20 Jul 2023	BH03_0.04-0.14	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.01	0.01	0.01	<1	-	0.01
	2.1 - 2.2	20 Jul 2023	BH03_2.1-2.2	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	12	-	<0.005
BH07	0	20 Jul 2023	BH07_BITUMEN	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<1	-	<0.005
			FD01	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<1	-	<0.005
			FS01	2	EM2313591	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.0004	0.0004	-	0.0004	-	0.2	-
	1 - 1.1	20 Jul 2023	BH07_1.0-1.1	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	9.5	-	<0.005
	2.6 - 2.7	20 Jul 2023	BH07_2.6-2.7	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	5.6	-	<0.005
BH08	0	20 Jul 2023	BH08_BITUMEN	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<1	-	<0.005
	0.05 - 0.15	20 Jul 2023	BH08_0.05-0.15	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0064	0.0064	<1	-	0.0064
			FD02	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.01	0.01	0.01	<1	-	0.01
			FS02	2	EM2313591	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	0.0012	<0.0005	0.0192	0.0166	-	0.0129	-	1.4	-
	0.35 - 0.45	20 Jul 2023	BH08_0.35-0.45	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0589	0.0504	0.044	0.0504	1.3	-	0.0504
	3.2 - 3.3	20 Jul 2023	BH08_3.2-3.3	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	6.5	-	<0.005
BH09	0 - 0.15	20 Jul 2023	BH09_0-0.15	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.38	<0.005	<0.01	0.043	1.0461	0.393	0.35	0.35	12	-	0.35
	3.4 - 3.5	20 Jul 2023	BH09_3.4-3.5	2	1010934	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	12	-	<0.005
BH13	0 - 0.1	10 Apr 2024	BH13_0.0-0.1	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	3.5	-	<0.005
	0.4 - 0.5	10 Apr 2024	BH13_0.4-0.5	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.011	0.011	0.011	3.2	-	0.011
BH14	0 - 0.1	10 Apr 2024	BH14_0.0-0.1	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0581	0.036	0.036	0.036	4.5	-	0.036
	0.4 - 0.5	10 Apr 2024	BH14_0.4-0.5	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0522	0.03	0.03	0.03	6.0	-	0.03
BH17		10 Apr 2024	QC03	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2874	0.1474	0.1354	0.142	12	-	0.1474
			QC03a	2	EM2406055	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.284	0.122	-	0.111	-	12.4	-
	1 - 1.1	10 Apr 2024	BH17_1.0-1.1	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2509	0.1869	0.18	0.1869	12	-	0.1869
	1.5 - 1.6	10 Apr 2024	BH17_1.5-1.6	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.24	0.12	0.11	0.12	10	-	0.12
BH18	0.4 - 0.5	10 Apr 2024	BH18_0.4-0.5	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.0724	0.866	0.85	0.866	2.9	-	0.866
BH19	0 - 0.1	10 Apr 2024	BH19_0.0-0.1	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.016	<0.005	<0.01	0.01	1.2203	1.0142	0.976	0.992	4.6	-	0.998
	0.4 - 0.5	10 Apr 2024	BH19_0.4-0.5	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	0.0077	6.8658	6.7242	6.619	**6.691**	8.8	-	6.71
	1 - 1.1	09 Jul 2024	BH19_1.0-1.1	2	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	0.025	<0.005	0.5994	0.4295	0.139	0.322	12	-	0.369
BH28	0.4 - 0.5	11 Apr 2024	BH28_0.4-0.5	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	0.038	0.0055	1.0422	1.0128	0.842	0.93	7.8	-	0.942
BH29	0.4 - 0.5	11 Apr 2024	BH29_0.4-0.5	2	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.3992	1.0504	0.9474	1.021	9.6	-	1.0284
	1 - 1.1	09 Jul 2024	BH29_1.0-1.1	2	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.6444	0.4738	0.43	0.468	12	-	0.468
BH30	0 - 0.1	13 Aug 2024	QC1A	2	EM2414005	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.514	0.290	-	0.288	-	16.2	-
		13 Aug 2024	BH30_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.554	0.34	0.34	0.34	14	-	0.34
			QC1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.501	0.27	0.27	0.27	14	-	0.27
BH31	0 - 0.1	13 Aug 2024	BH31_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.025	0.025	0.025	8.2	-	0.025
BH32	0 - 0.1	13 Aug 2024	BH32_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.12	0.12	0.12	0.12	7.9	-	0.12
BH33	0 - 0.1	13 Aug 2024	BH33_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.4717	1.31	1.3	1.31	15	-	1.31
	0.4 - 0.5	13 Aug 2024	BH33_0.4-0.5	2	1132369	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.8135	1.7308	1.7058	1.725	14	-	1.7308
	0.9 - 1	13 Aug 2024	BH33_0.9-1.0	2	1134925	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.7574	1.6384	0.735	1.4	14	-	1.495
BH34	0 - 0.1	13 Aug 2024	BH34_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.661	1.414	1.4	1.414	18	-	1.414
	0.4 - 0.5	13 Aug 2024	BH34_0.4-0.5	2	1132369	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	2.7358	2.497	2.414	**2.483**	17	-	2.497
	0.9 - 1	13 Aug 2024	BH34_0.9-1.0	2	1134925	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	2.273	2.01	0.38	1.68	18	-	1.78
BH35	0 - 0.1	13 Aug 2024	BH35_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	0.013[#2]	0.018	<0.005	<0.01	0.028	8.3886	7.7695	7.628	**7.683**	11	-	7.711
	0.4 - 0.5	13 Aug 2024	BH35_0.4-0.5	2	1132369	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	0.0061[#2]	<0.005	<0.005	<0.01	0.014	11.3253	10.1842	8.96	**9.9**	13	-	10.06
BH36	0 - 0.1	13 Aug 2024	BH36_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.035	<0.005	<0.01	0.011	0.7293	0.3478	0.3258	0.331	16	-	0.3368
BH37	0 - 0.1	13 Aug 2024	BH37_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.1223	0.1	0.1	0.1	13	-	0.1
BH38	0 - 0.1	13 Aug 2024	BH38_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0673	0.061	0.061	0.061	12	-	0.061
BH39	0 - 0.1	13 Aug 2024	BH39_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0062	<0.005	<0.01	0.018	0.4833	0.2571	0.2391	0.23	10	-	0.2391
BH40	0 - 0.1	13 Aug 2024	BH40_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0053	<0.005	<0.01	<0.005	0.4814	0.09	0.09	0.09	12	-	0.09
BH41	0.4 - 0.5	13 Aug 2024	SS10/BH41_0.4-0.5	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.6686	0.3866	0.229	0.33	14	-	0.369
BH42	0.4 - 0.5	13 Aug 2024	SS10/BH42_0.4-0.5	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	0.011	1.7016	1.322	0.812	1.17	13	-	1.252
BH43	0 - 0.1	13 Aug 2024	BH43_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0073	0.0073	10	-	0.0073
BH44	0 - 0.1	13 Aug 2024	BH44_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.01	0.01	0.01	11	-	0.01
BH45	0 - 0.1	13 Aug 2024	BH45_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.023	0.023	0.023	7.5	-	0.023
BH46	0 - 0.1	13 Aug 2024	BH46_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0095	0.0095	14	-	0.0095
BH47	0 - 0.1	13 Aug 2024	BH47_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.175	0.11	0.11	0.11	17	-	0.11
BH48	0.2 - 0.3	13 Aug 2024	BH48_0.2-0.3	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.149	<0.01	<0.005	<0.005	17	-	<0.005
BH49	0 - 0.1	14 Aug 2024	QC3A	2	EM2414005	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.0609	0.0591	-	0.0585	-	16.9	-
		13 Aug 2024	BH49_0.0-0.1	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.063	0.063	0.063	0.063	16	-	0.063
			QC3	2	1129117	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.063	0.063	0.063	0.063	16	-	0.063
SS07	0 - 0.1	09 Jul 2024	SS07	2	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.153	0.14	0.14	0.14	0.14	6.9	-
SS08	0 - 0.1	09 Jul 2024	SS08	2	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0067	<0.005	<0.01	<0.005	0.6297	0.434	0.42	0.434	0.434	15	-
SS09	0 - 0.1	09 Jul 2024	SS09	2	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.042	<0.005	<0.01	<0.005	0.8765	0.3191	0.31	0.3191	0.3191	19	-
SS10	0 - 0.1	09 Jul 2024	SS10	2	1117313	<0.005	<0.01[#1]	<0.005	<0.005	<0.01	<0.005	0.036[#1]	0.026	<0.005	<0.01	0.0084	11.9765	11.3032	11.037	**11.16**	11.197	12	-
SS11	0 - 0.1	09 Jul 2024	SS11	2	1117313	<0.005	<0.01[#1]	<0.005	<0.005	<0.01	<0.005	0.036[#1]	0.029	<0.005	<0.01	0.0083	11.9112	11.2867	11.035	**11.15**	11.185	8.0	-
SS12	0 - 0.1	09 Jul 2024	SS12	2	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.036	0.036	0.036	0.036	18	-
SS13	0 - 0.1	09 Jul 2024	SS13	2	1117313	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.11	0.095	0.095	0.095	0.095	16	-

Comments

#1 If the concentration of PFHxS > PFOS this guideline value needs to be adjusted accordingly. Please r

#2 Quantification of linear and branched isomers has been conducted as a single total response using th

Environmental Standards

HEPA, Jan 2020, PFAS NEMP 2.0 2020 Residential with garden/accessible soil (HIL A)
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Residential w/ min opportunities for soil access (HIL B)
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Public open space (HIL C)
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Industrial/ commercial (HIL D)

						Misc.	Inorganics	PFAS - Perfluoroalkyl Sulfonic Acids								PFAS - Perfluoroalkyl Carboxylic Acids											PFAS - Perfluoroalkyl Sulfonamide							PFAS - Fluorotelomer Sulfonic Acids				PFAS - Sums				
						% Moisture_	Moisture (%)	Perfluorobutane sulfonic acid (PFBS)	Perfluorodecanesulfonic acid (PFDS)	Perfluorononane sulfonate (PFNS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluoropropanesulfonic acid (PFPrS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)	Perfluorobutanoic acid (PFBA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoDA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorooctanoic acid (PFOA)	Perfluoropentanoic acid (PFPeA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnDA)	N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-Methyl perfluorooctane sulfonamidoethanol (MEFOSE)	Perfluorooctane sulfonamide (FOSA)	10:2 Fluorotelomer sulfonic acid (10:2 FTS)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer Sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	PFAS (Sum of Total)	PFAS (Sum of Total)(WA DER List)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of PFHxS and PFOS	Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*
						%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL						1	0.1	0.0002	0.0002	0.005	0.0002	0.0002	0.005	0.0002	0.0002	0.001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0002	0.0002	0.0005	0.0002	0.0005	0.0005	0.0002	0.0005	0.0002	0.0005	0.0005	0.0005	0.0005	0.0002	0.0002	0.005	0.0002	0.005
PFAS NEMP 2.0 2020 Ecological direct exposure												1										10																				
PFAS NEMP 2.0 2020 Ecological indirect exposure												0.01																														
Location	Depth	Date	Field ID	Zone	Lab Report Number																																					
Zone 1 - The site																																										
BH01	0 - 0.13	19 Jul 2023	BH01_0-0.13	1	1010934	5.0	-	<0.005	<0.005	<0.005	<0.005	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.013	0.013	0.013	0.013
	3.4 - 3.5	19 Jul 2023	BH01_3.4-3.5	1	1010934	10	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH02	0.35 - 0.45	19 Jul 2023	BH02_0.35-0.45	1	1010934	16	-	<0.005	<0.005	0.025#1	<0.005	3.6#1	<0.005	<0.005	0.078#1	<0.005	0.012	0.0076#1	0.0063#1	0.015	0.0054	0.024#1	<0.005	<0.005	0.072#1	0.37#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0081	<0.005	<0.01	0.033	4.2564	3.7563	3.624	3.678	3.702
	2.7 - 2.8	19 Jul 2023	BH02_2.7-2.8	1	1010934	7.6	-	0.013#1	<0.005	<0.005	<0.005	<0.005	0.0059	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0064	0.091#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.1163	0.0194	<0.005	<0.005	<0.005
BH04	0.4 - 0.5	20 Jul 2023	BH04_0.4-0.5	1	1010934	17	-	<0.005	<0.005	<0.005	<0.005	0.46#1	<0.005	<0.005	0.016#1	<0.005	0.013	<0.005	<0.005	<0.005	0.0056	0.0079#1	<0.005	<0.005	0.016#1	0.21#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.011	<0.005	<0.01	0.029	0.7685	0.5129	0.4679	0.476	0.4839
	2.1 - 2.2	20 Jul 2023	BH04_2.1-2.2	1	1010934	7.5	-	<0.005	<0.005	<0.005	<0.005	0.029#1	<0.005	<0.005	0.019#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.03#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.078	0.048	0.029	0.048	0.048
BH05		20 Jul 2023	BH05_CONCRETE	1	1010934	2.2	-	0.012#1	<0.005	<0.005	0.013#1	0.23#1	<0.005	0.015#1	0.15#1	<0.005	<0.005	<0.005	0.0061#1	0.037	<0.005	0.017#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	0.024	<0.005	0.5041	0.4761	0.247	0.38	0.397
	0.12 - 0.2	20 Jul 2023	BH05_0.12-0.2	1	1010934	3.5	-	<0.005	<0.005	<0.005	<0.005	0.0099#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0099	0.0099	0.0099
	1.8 - 1.9	20 Jul 2023	BH05_1.8-1.9	1	1010934	9.2	-	0.0052	<0.005	<0.005	<0.005	<0.005	<0.005	0.0053	0.0079#1	<0.005	<0.005	<0.005	<0.005	0.0058	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.0189	<0.005	0.0079	0.0079
BH06		20 Jul 2023	BH06_CONCRETE	1	1010934	2.2	-	0.032#1	<0.005	<0.005	<0.005	0.024#1	0.0079	0.033#1	0.11#1	<0.005	<0.005	<0.005	0.0095#1	0.076	<0.005	0.0079#1	0.012	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.3123	0.2714	0.0319	0.134	0.1419
	0.15 - 0.35	20 Jul 2023	BH06_0.15-0.35	1	1010934	2.8	-	<0.005	<0.005	<0.005	<0.005	0.13#1	<0.005	<0.005	0.015#1	<0.005	<0.005	<0.005	<0.005	0.0060	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.151	0.151	0.13	0.145	0.145
			FD03	1	1010934	2.3	-	<0.005	<0.005	<0.005	<0.005	0.094#1	<0.005	<0.005	0.011#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.105	0.105	0.094	0.105	0.105
			FS03	1	EM2313591	-	1.7	0.0022	0.0003	-	0.0019	0.114	-	0.0031	0.0149	<0.001	<0.0002	<0.0002	0.0006	0.0068	0.0005	0.0021	0.0007	<0.0005	0.0002	0.0005	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.148	0.141	-	0.129	-
	2.4 - 2.5	20 Jul 2023	BH06_2.4-2.5	1	1010934	8.3	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH10	0.12 - 0.3	21 Jul 2023	BH10_0.12-0.3	1	1010934	1.6	-	<0.005	<0.005	<0.005	<0.005	0.054#1	<0.005	<0.005	0.0093#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.024#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0873	0.0633	0.054	0.0633	0.0633
	1 - 1.1	21 Jul 2023	BH10_1.0-1.1	1	1010934	11	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH11	0.12 - 0.22	21 Jul 2023	BH11_0.12-0.22	1	1010934	4.3	-	<0.005	<0.005	<0.005	<0.005	0.0080#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.008	0.008	0.008
	1.5 - 1.6	21 Jul 2023	BH11_1.5-1.6	1	1010934	13	-	<0.005	<0.005	<0.005	<0.005	0.064#1	<0.005	<0.005	0.054#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.118	0.118	0.064	0.118	0.118
BH12	0 - 0.1	10 Apr 2024	BH12_0.0-0.1	1	1088156	5.2	-	<0.005	<0.005	<0.005	<0.005	0.029#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0053	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.029	0.029	0.029	0.029
	0.05 - 0.15	21 Jul 2023	MW01_0.05-0.15	1	1010934	<1	-	<0.005	<0.005	<0.005	<0.005	<0.005#1	<0.005	<0.005	<0.005#1	<0.005	<0.005	<0.005	<0.005	<0.005#1	<0.005	<0.005#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	0.4 - 0.5	10 Apr 2024	BH12_0.4-0.5	1	1088156	8.8	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0070#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	0.007	0.007
	2 - 2.1	21 Jul 2023	MW01_2.0-2.1	1	1010934	8.1	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	4.5 - 5	04 Sep 2023	MW01_4.5-5.0	1	1023122	7.4	-	<0.005	<0.005	<0.005	<0.005	<0.005#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	10	04 Sep 2023	MW01_10.0	1	1023122	7.9	-	<0.005	<0.005	<0.005	<0.005	<0.005#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	15	04 Sep 2023	MW01_15.0	1	1023122	1.1	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	20	04 Sep 2023	MW01_20.0	1	1023122	<1	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH15		10 Apr 2024	QC02	1	1088156	12	-	0.0097#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.02#1	0.31#1	<0.005	<0.005	<0.005	0.012#1	0.025	<0.005	0.028#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.4047	0.3847	0.028	0.31	0.338
			QC02a	1	EM2406055	-	10.1	0.0106	<0.0002	-	0.0018	0.0016	-	0.0202	0.256	0.001	<0.0002	<0.0002	0.0110	0.0260	<0.0002	0.0201	0.0031	<0.0005	<0.0002	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.355	0.329	-	0.258	-
	0.4 - 0.5	10 Apr 2024	BH15_0.4-0.5	1	1088156	23	-	0.0062	<0.005	<0.005	<0.005	<0.005	<0.005	0.013#1	0.22#1	<0.005	<0.005	<0.005	0.0085#1	0.016	<0.005	0.022#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2857	0.2727	0.022	0.22	0.242
	1 - 1.1	10 Apr 2024	BH15_1.0-1.1	1	1088156	12	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH16	0.4 - 0.5	10 Apr 2024	BH16_0.4-0.5	1	1088156	9.9	-	<0.005	<0.005	<0.005	<0.005	0.081#1	<0.005	<0.005	0.058#1	<0.005	0.0083#1	<0.005	0.018#1	0.0076	0.033#1	0.027#1	<0.005	<0.005	0.037	0.28#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	0.0093	0.5592	0.2009	0.108	0.139	0.166
	1 - 1.1	10 Apr 2024	BH16_1.0-1.1	1	1088156	10	-	<0.005	<0.005	<0.005	<0.005	0.081#1	<0.005	<0.005	0.0074#1	<0.005	0.0063#1	<0.005	<0.005	<0.005	0.069#1	<0.005	<0.005	<0.005	<0.005	0.06#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2237	0.0884	0.081	0.0884	0.0884
BH20	0 - 0.1	10 Apr 2024	BH20_0.0-0.1	1	1088156	2.0	-	<0.005	<0.005	<0.005	<0.005	0.0094#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	0.022#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0094	0.0094	0.0094
	0.4 - 0.5	10 Apr 2024	BH20_0.4-0.5	1	1088156	9.4	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH21		10 Apr 2024	QC05	1	1088156	14	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012#1	<0.005	0.023#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.012	<0.005	<0.005	<0.005
			QC05a	1	EM2406055	-	12.0	<0.0002	<0.0002	-	<0.0002	<0.0002	-	<0.0002	0.0005	<0.001	<0.0002	<0.0002	0.0065	0.0013	0.0095	0.0012	0.0007	<0.0005	<0.0002	0.0006	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.0203	0.0102	-	0.0005	-
	0 - 0.1	10 Apr 2024	BH21_0.0-0.1	1	1088156	2.2	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	0.4 - 0.5	10 Apr 2024	BH21_0.4-0.5	1	1088156	14	-	<0.005	<0.005	<0.005	<0.005	0.057#1	<0.005	<0.005	0.0069#1	<0.005	0.027#1	<0.005	<0.005	<0.005	0.33#1	0.0057	<0.005	<0.005	0.047	0.34#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.8136	0.0696	0.0627	0.0639	0.0696
	1.5 - 1.6	10 Apr 2024	BH21_1.5-1.6	1	1088156	14	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.015#1	<0.005	0.022#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.015	<0.005	<0.005	<0.005
BH22	0.4 - 0.5	10 Apr 2024	BH22_0.4-0.5	1	1088156	13	-	0.0080#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.0067#1	0.016#1	<0.005	<0.005	<0.005	0.015#1	0.014	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0597	0.053	<0.005	0.016	0.016
	1.5 - 1.6	10 Apr 2024	BH22_1.5-1.6	1	1088156	9.5	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH23	0.4 - 0.5	10 Apr 2024	BH23_0.4-0.5	1	1088156	<1	-	<0.005	<0.005	<0.005	<0.005	0.015#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.017#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.015	0.015	0.015	0.015
	1.5 - 1.6	10 Apr 2024	BH23_1.5-1.6	1	1088156	11	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH24		10 Apr 2024	QC07	1	1088156	3.2	-	<0.005	<0.005	<0.005	<0.005	0.017#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0059#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.017	0.017	0.017	0.017
			QC07a	1	EM2406055	-	3.1	<0.0002	0.0004	-	<0.0002	0.0077	-	<0.0002	<0.0002	<0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	<0.0002	0.0032	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	0.0003	<0.0005	<0.0005	<0.0005	<0.0005	0.0116	0.0077	-	0.0077	-
	0.4 - 0.5	10 Apr 2024	BH24_0.4-0.5	1	1088156	3.1	-	<0.005	<0.005	<0.005	<0.005	0.0082	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0082	0.0082	0.0082
	1.5 - 1.6	10 Apr 2024	BH24_1.5-1.6	1	1088156	28	-	<0.005	<0.005	<0.005	0.0098#1	0.71#1	<0.005	<0.005	0.012#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.057#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.7888	0.722	0.71	0.722	0.722
BH25	1.5 - 1.6	10 Apr 2024	BH25_1.5-1.6	1	1088156	14	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	1.9 - 2	10 Apr 2024	BH25_1.9-2.0	1	1088156	11	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH26	0 - 0.1	11 Apr 2024	BH26_0.0-0.1	1	1088156	5.5	-	<0.005	<0.005	<0.005	<0.005	0.13#1	<0.005	<0.005	0.0067#1	<0.005	0.012	0.017#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.17	0.055#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.085	<0.005	<0.01	0.01	0.4857	0.1467	0.13	0.1367	0.1367
	0.4 - 0.5	11 Apr 2024	BH26_0.4-0.5	1	1088156	9.1	-	<0.005	<0.005	<0.005	<0.005	1.6#1	<0.005	<0.005	0.025#1	<0.005	0.027	<0.005	0.0081#1	0.011	0.0070#1	0.012#1	0.0073	<0.005	0.017	0.62#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.014	<0.005	0.019	0.042	2.4094	1.7244	1.612	1.625	1.637
	1 - 1.1	09 Jul 2024	BH26_1.0-1.1	1	1117313	13	-	<0.005	<0.005	<0.005	0.0063#1	0.4#1	<0.005	<0.005	0.024#1	<0.005	0.034	<0.005	0.0088	0.0067	0.02	0.015#1	<0.005	<0.005	<0.005	0.39	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	0.015	0.064	0.9838	0.5335	0.415	0.424	0.439
BH27	0 - 0.1	11 Apr 2024	BH27_0.0-0.1	1	1088156	3.4	-	<0.005	0.012#1	0.011#1	<0.005	0.56#1	<0.005	<0.005	0.011#1	<0.005	0.0090	0.0086#1	<0.005	<0.005	0.0058#1	0.0083#1	<0.005	<0.005	0.05	0.041#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0078	<0.005	<0.01	0.027	0.7515	0.6063	0.5683	0.571	0.5793
	0.4 - 0.5	11 Apr 2024	BH27_0.4-0.5	1	1088156	11	-	<0.005	0.0052	0.045#1	<0.005	3.8#1	<0.005	<0.005	0.029#1	<0.005	<0.005	<0.005	0.0083#1	0.0050	0.022#1	0.018#1	<0.005	<0.005	0.0088	0.0085#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	0.063	4.0128	3.9233	3.818	3.829	3.847
	1 - 1.1	09 Jul 2024	BH27_1.0-1.1	1	1117313	29	-	<0.005	<0.005	<0.005	0.066	0.8	<0.005	<0.005	0.1	<0.005	<0.005	<0.005	<0.005	0.0068#1	0.018	0.0079#1	<0.005	<0.005	<0.005	0.0053	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.004	0.9147	0.8079	0.9	0.9079
MW02	0.12 - 0.32	21 Jul 2023	FD04	1	1010934	2.1	-	<0.005	<0.005	<0.005	<0.005	0.057#1	<0.005	<0.005	0.0079#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0649	0.0649	0.057	0.0649	0.0649
			FS04	1	EM2313591	-	2.5	<0.0002	0.0006	-	0.0004	0.0506	-	0.0002	0.0080	<0.001	0.0002	<0.0002	<0.0002	0.0023	0.0019	0.0006	<0.0002	<0.0005	0.0013	0.0036	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.0697	0.0615	-	0.0586	-
			MW02_0.12-0.32	1	1010934	2.7	-	<0.005	<0.005	<0.005	<0.005	0.054#1	<0.005	<0.005	0.0079#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0619	0.0619	0.054	0.0619	0.0619
	2.2 - 2.3	21 Jul 2023	MW02_2.2-2.3	1	1010934	10	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
MW03	0.12 - 0.22	21 Jul 2023	MW03_0.12-0.22	1	1010934	3.9	-	<0.005	<0.005	<0.005	<0.005	0.073#1	<0.005	<0.005	0.012#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.06#1	<0.005	<0.005	<0.005	0.021#1	0.033#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.199	0.085	0.073	0.085	0.085
	3.4 - 3.5	21 Jul 2023	MW03_3.4-3.5	1	1010934	12	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
SS01	0 - 0.1	21 Jul 2023	FD05	1	1010934	29	-	<0.005	<0.005	<0.005	<0.005	0.07#1	<0.005	<0.005	0.011#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.0051	<0.005	<0.005	<0.005	0.058#1	0.059#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2031	0.081	0.07	0.081	0.081
			FS05	1	EM2313591	-	28.6	<0.0002	0.0008	-	<0.0002	0.0386	-	0.0003	0.0047	<0.001	0.0011	0.0020	0.0002	0.0004	0.0025	0.0006	0.0006	<0.0005	0.0447	0.0329	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.129	0.0451	-	0.0433	-
			SS01	1	1010934	30	-	<0.005	<0.005	<0.005	<0.005	0.066#1	<0.005	<0.005	0.0068	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.067#1	0.054#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.1938	0.0728	0.066	0.0728	0.0728
SS02	0 - 0.1	21 Jul 2023	SS02	1	1010934	11	-	<0.005	<0.005	<0.005	<0.005	0.0064#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.013#1	0.0076#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0064	0.0064	0.0064
SS03		04 Sep 2023	SS03	1	1023122	18	-	<0.005	<0.005	<0.005	<0.005	0.25#1	<0.005	<0.005	0.0053#1	<0.005	0.014	0.0084	<0.005	<0.005	0.0068	<0.005	<0.005	<0.005	0.21	0.079	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.01	<0.005	<0.01	<0.005	0.5835	0.2553	0.25	0.2553	0.2553
SS04		04 Sep 2023	SS04	1	1023122	6.7	-	<0.005	<0.005	<0.005	<0.005	0.03#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005#1	<0.005	<0.005	<0.005	0.1	0.038	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0073	<0.005	<0.01	<0.005	0.1753	0.03	0.03	0.03	0.03
SS05		04 Sep 2023	SS05	1	1023122	24	-	<0.005	<0.005	<0.005	<0.005	0.091#1	<0.005	<0.005	<0.005#1	<0.005	0.011	0.0098	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.33	0.049	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.015	<0.005	<0.01	<0.005	0.5058	0.091	0.091	0.091	0.091
SS06		04 Sep 2023	SS06	1	1023122	3.7	-	<0.005	<0.005	<0.005	<0.005	<0.005#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0063	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
SS14		09 Jul 2024	SS14	1	1117313	11	-	<0.005	<0.005	<0.005	<0.005	0.022#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.032	0.028	<0.005	<0.01	<0.005	<0.005	<0.01	0.0056	<0.005	<0.005	<0.005	<0.01	<0.005	0.0876	0.022	0.022	0.022	0.022
SS15		09 Jul 2024	SS15	1	1117313	13	-	<0.005	<0.005	0.0096	<0.005	0.74#1	<0.005	<0.005	0.066	<0.005	0.016	0.0055	<0.005	0.0075#1	0.068	<0.005	<0.005	<0.005	0.19	0.45	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0099	<0.005	<0.01	<0.005	1.5625	0.8135	0.74	0.806	0.806

Location	Depth	Date	Field ID	Zone	Lab Report Number	Misc.	Inorganics	PFAS - Perfluoroalkyl Sulfonic Acids								PFAS - Perfluoroalkyl Carboxylic Acids											PFAS - Perfluoroalkyl Sulfonamide							PFAS - Fluorotelomer Sulfonic Acids				PFAS - Sums				
						% Moisture_	Moisture (%)	Perfluorobutane sulfonic acid (PFBS)	Perfluorodecanesulfonic acid (PFDS)	Perfluorononane sulfonate (PFNS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluoropropanesulfonic acid (PFPrS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)	Perfluorobutanoic acid (PFBA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoDA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorooctanoic acid (PFOA)	Perfluoropentanoic acid (PFPeA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnDA)	N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-Methyl perfluorooctane sulfonamidoethanol (MEFOSE)	Perfluorooctane sulfonamide (FOSA)	10:2 Fluorotelomer sulfonic acid (10:2 FTS)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer Sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	PFAS (Sum of Total)	PFAS (Sum of Total)(WA DER List)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of PFHxS and PFOS	Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*
						%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL						1	0.1	0.0002	0.0002	0.005	0.0002	0.0002	0.005	0.0002	0.0002	0.001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0002	0.0002	0.0005	0.0002	0.0005	0.0005	0.0002	0.0005	0.0002	0.0005	0.0005	0.0005	0.0005	0.0002	0.0002	0.005	0.0002	0.005
PFAS NEMP 2.0 2020 Ecological direct exposure												1										10																				
PFAS NEMP 2.0 2020 Ecological indirect exposure												0.01																														
Zone 2 - Holman Rd and the reserve area																																										
BH03		20 Jul 2023	BH03_BITUMEN	2	1010934	<1	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	0.04 - 0.14	20 Jul 2023	BH03_0.04-0.14	2	1010934	<1	-	<0.005	<0.005	<0.005	<0.005	0.0100	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.01	0.01	0.01	0.01
	2.1 - 2.2	20 Jul 2023	BH03_2.1-2.2	2	1010934	12	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH07		20 Jul 2023	BH07_BITUMEN	2	1010934	<1	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
			FD01	2	1010934	<1	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
			FS01	2	EM2313591	-	0.2	<0.0002	<0.0002	-	<0.0002	0.0004	-	<0.0002	<0.0002	<0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	<0.0002	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.0004	0.0004	-	0.0004	-
	1 - 1.1	20 Jul 2023	BH07_1.0-1.1	2	1010934	9.5	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	2.6 - 2.7	20 Jul 2023	BH07_2.6-2.7	2	1010934	5.6	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH08		20 Jul 2023	BH08_BITUMEN	2	1010934	<1	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	0.05 - 0.15	20 Jul 2023	BH08_0.05-0.15	2	1010934	<1	-	<0.005	<0.005	<0.005	<0.005	0.0064#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0064	0.0064	0.0064
			FD02	2	1010934	<1	-	<0.005	<0.005	<0.005	<0.005	0.01#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.01	0.01	0.01	0.01
			FS02	2	EM2313591	-	1.4	<0.0002	<0.0002	-	<0.0002	0.0113	-	<0.0002	0.0016	<0.001	<0.0002	<0.0002	<0.0002	0.0016	0.0007	<0.0002	0.0009	<0.0005	<0.0002	0.0019	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	0.0012	<0.0005	0.0192	0.0166	-	0.0129	-
	0.35 - 0.45	20 Jul 2023	BH08_0.35-0.45	2	1010934	1.3	-	<0.005	<0.005	<0.005	<0.005	0.044#1	<0.005	<0.005	0.0064#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0085	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0589	0.0504	0.044	0.0504	0.0504
	3.2 - 3.3	20 Jul 2023	BH08_3.2-3.3	2	1010934	6.5	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH09	0 - 0.15	20 Jul 2023	BH09_0-0.15	2	1010934	12	-	<0.005	<0.005	0.0061#1	<0.005	0.35#1	<0.005	<0.005	<0.005	<0.005	0.027	0.018#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.0050	0.14	0.077	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.38	<0.005	<0.01	0.043	1.0461	0.393	0.35	0.35	0.35
	3.4 - 3.5	20 Jul 2023	BH09_3.4-3.5	2	1010934	12	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
BH13	0 - 0.1	10 Apr 2024	BH13_0.0-0.1	2	1088156	3.5	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0076#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005	<0.005
	0.4 - 0.5	10 Apr 2024	BH13_0.4-0.5	2	1088156	3.2	-	<0.005	<0.005	<0.005	<0.005	0.011#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0070	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.011	0.011	0.011	0.011
BH14	0 - 0.1	10 Apr 2024	BH14_0.0-0.1	2	1088156	4.5	-	<0.005	<0.005	<0.005	<0.005	0.036#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0051	0.017#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0581	0.036	0.036	0.036	0.036
	0.4 - 0.5	10 Apr 2024	BH14_0.4-0.5	2	1088156	6.0	-	<0.005	<0.005	<0.005	<0.005	0.03#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.016#1	<0.005	<0.005	<0.005	<0.005	0.0062#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0522	0.03	0.03	0.03	0.03
BH17		10 Apr 2024	QC03	2	1088156	12	-	<0.005	<0.005	<0.005	<0.005	0.13#1	<0.005	<0.005	0.012	<0.005	<0.005	<0.005	<0.005	<0.005	0.14#1	0.0054	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2874	0.1474	0.1354	0.142	0.1474
			QC03a	2	EM2406055	-	12.4	0.0007	<0.0002	-	0.0006	0.101	-	0.0006	0.0100	<0.001	0.0007	<0.0002	0.0029	0.0024	0.159	0.0036	0.0015	<0.0005	<0.0002	0.0007	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.284	0.122	-	0.111	-
	1 - 1.1	10 Apr 2024	BH17_1.0-1.1	2	1088156	12	-	<0.005	<0.005	<0.005	<0.005	0.18#1	<0.005	<0.005	0.0069#1	<0.005	0.0070#1	<0.005	<0.005	<0.005	0.039#1	<0.005	<0.005	<0.005	<0.005	0.018#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.2509	0.1869	0.18	0.1869	0.1869
	1.5 - 1.6	10 Apr 2024	BH17_1.5-1.6	2	1088156	10	-	<0.005	<0.005	<0.005	<0.005	0.11#1	<0.005	<0.005	0.01#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.12#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.24	0.12	0.11	0.12	0.12
BH18	0.4 - 0.5	10 Apr 2024	BH18_0.4-0.5	2	1088156	2.9	-	<0.005	<0.005	<0.005	<0.005	0.85#1	<0.005	<0.005	0.016#1	<0.005	0.0064#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.2#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.0724	0.866	0.85	0.866	0.866
BH19	0 - 0.1	10 Apr 2024	BH19_0.0-0.1	2	1088156	4.6	-	<0.005	0.014#1	0.017#1	<0.005	0.97#1	<0.005	<0.005	0.022#1	<0.005	0.0095	0.0056#1	<0.005	0.0062	<0.005	0.0060#1	<0.005	<0.005	0.034	0.11	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.016	<0.005	<0.01	0.01	1.2203	1.0142	0.976	0.992	0.998
	0.4 - 0.5	10 Apr 2024	BH19_0.4-0.5	2	1088156	8.8	-	<0.005	<0.005	<0.005	0.036#1	6.6#1	<0.005	<0.005	0.091#1	<0.005	<0.005	<0.005	<0.005	0.0065	0.1#1	0.019#1	<0.005	<0.005	<0.005	0.0056#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	0.0077	6.8658	6.7242	6.619	6.691	6.71
	1 - 1.1	09 Jul 2024	BH19_1.0-1.1	2	1117313	12	-	<0.005	<0.005	<0.005	0.0057	0.092#1	<0.005	0.0056	0.23#1	<0.005	<0.005	<0.005	0.014	0.012	0.15	0.047#1	0.0095	<0.005	<0.005	0.0086	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	0.025	<0.005	0.5994	0.4295	0.139	0.322	0.369
BH28	0.4 - 0.5	11 Apr 2024	BH28_0.4-0.5	2	1088156	7.8	-	<0.005	<0.005	<0.005	0.01	0.83#1	<0.005	<0.005#1	0.1#1	<0.005	<0.005	<0.005	0.0052	0.016	0.012	0.012	0.0061	<0.005	<0.005	0.0074	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	0.038	0.0055	1.0422	1.0128	0.842	0.93	0.942
BH29	0.4 - 0.5	11 Apr 2024	BH29_0.4-0.5	2	1088156	9.6	-	<0.005	<0.005	<0.005	0.0058	0.94#1	<0.005	<0.005#1	0.081#1	<0.005	0.0069	0.0081	<0.005	0.022	0.038	0.0074	<0.005	<0.005	0.16	0.13	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.3992	1.0504	0.9474	1.021	1.0284
	1 - 1.1	09 Jul 2024	BH29_1.0-1.1	2	1117313	12	-	<0.005	<0.005	0.0054	0.0072	0.43	<0.005	<0.005	0.038	<0.005	<0.005	<0.005	<0.005	0.0058#1	0.035	<0.005	<0.005	<0.005	0.025	0.098	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.6444	0.4738	0.43	0.468	0.468
BH30		13 Aug 2024	QC1A	2	EM2414005	-	16.2	<0.0002	0.0018	-	0.0005	0.287	-	<0.0002	0.0014	<0.001	0.0092	0.0022	0.0002	0.0004	0.0254	0.0005	0.0004	<0.0005	0.0674	0.118	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.514	0.290	-	0.288	-
	0 - 0.1	13 Aug 2024	BH30_0.0-0.1	2	1129117	14	-	<0.005	<0.005	<0.005	<0.005	0.34#1	<0.005	<0.005	<0.005	<0.005	0.011#1	<0.005	<0.005	<0.005	0.026#1	<0.005	<0.005	<0.005	0.047#1	0.13#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.554	0.34	0.34	0.34	0.34
			QC1	2	1129117	14	-	<0.005	<0.005	<0.005	<0.005	0.27#1	<0.005	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	0.025	<0.005	<0.005	<0.005	0.036	0.16	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.501	0.27	0.27	0.27	0.27
BH31	0 - 0.1	13 Aug 2024	BH31_0.0-0.1	2	1129117	8.2	-	<0.005	<0.005	<0.005	<0.005	0.025#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.025	0.025	0.025	0.025
BH32	0 - 0.1	13 Aug 2024	BH32_0.0-0.1	2	1129117	7.9	-	<0.005	<0.005	<0.005	<0.005	0.12#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.12	0.12	0.12	0.12	0.12
BH33	0 - 0.1	13 Aug 2024	BH33_0.0-0.1	2	1129117	15	-	<0.005	0.015#1	0.035#1	<0.005	1.3#1	<0.005	<0.005	0.01#1	<0.005	0.01#1	<0.005	<0.005	<0.005	0.0067#1	<0.005	<0.005	<0.005	0.032#1	0.063#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.4717	1.31	1.3	1.31	1.31
	0.4 - 0.5	13 Aug 2024	BH33_0.4-0.5	2	1132369	14	-	<0.005	0.012#1	0.021#1	<0.005	1.7#1	<0.005	<0.005	0.025#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.022#1	0.0058	<0.005	<0.005	0.0077	0.02	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.8135	1.7308	1.7058	1.725	1.7308
	0.9 - 1	13 Aug 2024	BH33_0.9-1.0	2	1134925	14	-	0.028	<0.005	<0.005	0.05#1	0.64#1	0.012	0.028#1	0.76#1	<0.005	<0.005	<0.005	0.0084#1	0.09#1	0.029	0.095#1	0.017	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.7574	1.6384	0.735	1.4	1.495
BH34	0 - 0.1	13 Aug 2024	BH34_0.0-0.1	2	1129117	18	-	<0.005	0.017#1	0.064#1	<0.005	1.4#1	<0.005	<0.005	0.014#1	<0.005	0.017#1	<0.005	<0.005	<0.005	0.0090#1	<0.005	<0.005	<0.005	0.03#1	0.11#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.661	1.414	1.4	1.414	1.414
	0.4 - 0.5	13 Aug 2024	BH34_0.4-0.5	2	1132369	17	-	<0.005	<0.005	0.011#1	0.043#1	2.4#1	<0.005	<0.005	0.083#1	<0.005	<0.005	<0.005	<0.005	<0.005	0.15#1	0.014#1	<0.005	<0.005	0.0088	0.026	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	2.7358	2.497	2.414	2.483	2.497
	0.9 - 1	13 Aug 2024	BH34_0.9-1.0	2	1134925	18	-	0.045	<0.005	<0.005	0.078#1	0.28#1	0.017	0.11#1	1.4#1	0.0090	<0.005	<0.005	0.034#1	0.12#1	0.058	0.1#1	0.022	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	2.273	2.01	0.38	1.68	1.78
BH35	0 - 0.1	13 Aug 2024	BH35_0.0-0.1	2	1129117	11	-	0.0085#1	0.015#1	0.066#1	0.041#1	7.6#1	0.0067	0.0052	0.083#1	<0.005	0.021#1	0.0052	<0.005	0.022	0.058#1	0.028#1	<0.005	<0.005	0.1#1	0.27#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	0.013#1	0.018	<0.005	<0.01	0.028	8.3886	7.7695	7.628	7.683	7.711
	0.4 - 0.5	13 Aug 2024	BH35_0.4-0.5	2	1132369	13	-	0.02#1	<0.005	<0.005	0.17	8.8#1	0.01	0.027	1.1	0.0074	0.016	<0.005	0.011#1	0.062	0.75	0.16	0.0098	<0.005	0.042	0.12	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	0.0061#1	<0.005	<0.005	<0.01	0.014	11.3253	10.1842	8.96	9.9	10.06
BH36	0 - 0.1	13 Aug 2024	BH36_0.0-0.1	2	1129117	16	-	<0.005	0.0073#1	0.0092#1	<0.005	0.32#1	<0.005	<0.005	0.011#1	<0.005	0.0100	0.01#1	<0.005	<0.005	<0.005	0.0058	<0.005	<0.005	0.18#1	0.13#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.035	<0.005	<0.01	0.011	0.7293	0.3478	0.3258	0.331	0.3368
BH37	0 - 0.1	13 Aug 2024	BH37_0.0-0.1	2	1129117	13	-	<0.005	<0.005	<0.005	<0.005	0.1#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0063#1	0.016#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.1223	0.1	0.1	0.1	0.1
BH38	0 - 0.1	13 Aug 2024	BH38_0.0-0.1	2	1129117	12	-	<0.005	<0.005	<0.005	<0.005	0.061#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0063#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.0673	0.061	0.061	0.061	0.061
BH39	0 - 0.1	13 Aug 2024	BH39_0.0-0.1	2	1129117	10	-	<0.005	<0.005	<0.005	<0.005	0.23#1	<0.005	<0.005	<0.005	<0.005	0.012#1	<0.005	<0.005	<0.005	0.075#1	0.0091#1	<0.005	<0.005	0.023#1	0.11#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0062	<0.005	<0.01	0.018	0.4833	0.2571	0.2391	0.23	0.2391
BH40	0 - 0.1	13 Aug 2024	BH40_0.0-0.1	2	1129117	12	-	<0.005	<0.005	<0.005	<0.005	0.09#1	<0.005	<0.005	<0.005	<0.005	0.0071	<0.005	<0.005	<0.005	0.25	<0.005	<0.005	<0.005	0.029	0.1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0053	<0.005	<0.01	<0.005	0.4814	0.09	0.09	0.09	0.09
BH41	0.4 - 0.5	13 Aug 2024	SS10/BH41_0.4-0.5	2	1129117	14	-	<0.005	<0.005	<0.005	0.0085#1	0.19#1	<0.005	<0.005	0.14#1	<0.005	<0.005	<0.005	0.0085#1	0.0091	0.24	0.039#1	<0.005	<0.005	0.0055	0.028	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.6686	0.3866	0.229	0.33	0.369
BH42	0.4 - 0.5	13 Aug 2024	SS10/BH42_0.4-0.5	2	1129117	13	-	0.014#1	<0.005	0.0066#1	0.034#1	0.73#1	<0.005	0.02#1	0.44#1	<0.005	<0.005	<0.005	0.011#1	0.034	0.26#1	0.082#1	<0.005	<0.005	0.018#1	0.041#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	0.011	1.7016	1.322	0.812	1.17	1.252
BH43	0 - 0.1	13 Aug 2024	BH43_0.0-0.1	2	1129117	10	-	<0.005	<0.005	<0.005	<0.005	0.0073#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0073	0.0073	0.0073
BH44	0 - 0.1	13 Aug 2024	BH44_0.0-0.1	2	1129117	11	-	<0.005	<0.005	<0.005	<0.005	0.01#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.01	0.01	0.01	0.01
BH45	0 - 0.1	13 Aug 2024	BH45_0.0-0.1	2	1129117	7.5	-	<0.005	<0.005	<0.005	<0.005	0.023#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.023	0.023	0.023	0.023
BH46	0 - 0.1	13 Aug 2024	BH46_0.0-0.1	2	1129117	14	-	<0.005	<0.005	<0.005	<0.005	0.0095#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0095	0.0095	0.0095
BH47	0 - 0.1	13 Aug 2024	BH47_0.0-0.1	2	1129117	17	-	<0.005	<0.005	<0.005	<0.005	0.11#1	<0.005	<0.005	<0.005	<0.005	0.015	0.012	<0.005	<0.005	0.038	<0.005	<0.005	<0.005	0.19	0.81	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	1.175	0.11	0.11	0.11	0.11
BH48	0.2 - 0.3	13 Aug 2024	BH48_0.2-0.3	2	1129117	17	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.13	<0.005	<0.005	<0.005	<0.005	0.019	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.149	<0.01	<0.005	<0.005	<0.005
BH49		14 Aug 2024	QC3A	2	EM2414005	-	16.9	<0.0002	<0.0002	-	0.0003	0.0571	-	<0.0002	0.0014	<0.001	<0.0002	<0.0002	<0.0002	0.0002	0.0003	0.0004	<0.0002	<0.0005	0.0005	0.0007	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	0.0609	0.0591	-	0.0585	-
	0 - 0.1	13 Aug 2024	BH49_0.0-0.1	2	1129117	16	-	<0.005	<0.005	<0.005	<0.005	0.063#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.063	0.063	0.063	0.063	0.063
			QC3	2	1129117	16	-	<0.005	<0.005	<0.005	<0.005	0.063#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.063	0.063	0.063	0.063	0.063
SS07		09 Jul 2024	SS07	2	1117313	6.9	-	<0.005	<0.005	<0.005	<0.005	0.14#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.013#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.153	0.14	0.14	0.14	0.14
SS08		09 Jul 2024	SS08	2	1117313	15	-	<0.005	0.016#1	0.027#1	<0.005	0.42#1	<0.005	<0.005	0.014#1	<0.005	0.013	<0.005	<0.005	<0.005	0.012	<0.005	<0.005	<0.005	0.021	0.1#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.0067	<0.005	<0.01	<0.005	0.6297	0.434	0.42	0.434	0.434
SS09		09 Jul 2024	SS09	2	1117313	19	-	<0.005	0.0089#1	0.0075#1	<0.005	0.31#1	<0.005	<0.005	0.0091#1	<0.005	0.018	0.011	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.13	0.34#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	0.042	<0.005	<0.01	<0.005	0.8765	0.3191	0.31	0.3191	0.3191
SS10		09 Jul 2024	SS10	2	1117313	12	-	0.021#1	0.021	0.098	<0.015#1	11#1	0.026	0.017#1	0.16#1	0.012	0.0063	0.013	0.0078#1	0.046	<0.005	0.037#1	0.011	<0.005	0.2	0.23#1	<0.005	<0.01#1	<0.005	<0.005	<0.01	<0.005	0.036#1	0.026	<0.005	<0.01	0.0084	11.9765	11.3032	11.037	11.16	11.197
SS11		09 Jul 2024	SS11	2	1117313	8.0	-	0.02#1	0.023	0.1	<0.015#1	11#1	0.024	0.016#1	0.15#1	0.012	0.0055	0.011	0.0074#1	0.043	<0.005	0.035#1	0.011	<0.005	0.17	0.21#1	<0.005	<0.01#1	<0.005	<0.005	<0.01	<0.005	0.036#1	0.029	<0.005	<0.01	0.0083	11.9112	11.2867	11.035	11.15	11.185
SS12		09 Jul 2024	SS12	2	1117313	18	-	<0.005	<0.005	<0.005	<0.005	0.036#1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	0.036	0.036	0.036	0.036
SS13		09 Jul 2024	SS13	2	1117313	16	-	<0.005	<0.005	<0.005	<0.005	0.095	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.015#1	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	0.11	0.095	0.095	0.095	0.095

Comments

#1 Quantification of linear and branched isomers has been conducted as a single total response using the relative response factor for the corresponding linear/branched standard.

Environmental Standards

HEPA, Jan 2020, PFAS NEMP 2.0 2020 Ecological direct exposure
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Ecological indirect exposure

Location	Depth	Date	Field ID	Lab Report Number	Leach Preparation: pH of Leaching Fluid	pH (Initial)	pH (Final)	PFAS - Perfluoroalkyl Sulfonic Acids: Perfluorobutane sulfonic acid (PFBS)	Perfluorodecanesulfonic acid (PFDS)	Perfluorononane sulfonate (PFNS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluoropropanesulfonic acid (PFPrS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)
					pH units	pH units	pH units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL					0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PFAS NEMP 2.0 2020 Freshwater - 95% (leached)												**0.13**			
PFAS NEMP 2.0 2020 Freshwater - 99% (leached)												0.00023			
BH19	1 - 1.1	09 Jul 2024	BH19_1.0-1.1	1125999	5.0	8.5	6.7	0.13[#1]	<0.01	<0.01	0.21[#1]	**2.5[#1]**	0.07	0.38	15[#1]
BH26	1 - 1.1	09 Jul 2024	BH26_1.0-1.1	1125999	5.0	8.6	6.8	0.02[#1]	<0.01	0.03[#1]	0.36[#1]	**9.5[#1]**	<0.01	0.04[#1]	0.78[#1]
BH27	1 - 1.1	09 Jul 2024	BH27_1.0-1.1	1125999	5.0	8.8	6.7	0.04[#1]	<0.01	<0.125[#2]	1.2[#1]	**69[#1]**	<0.01	0.09[#1]	2.5[#1]
BH35		15 Aug 2024	BH35_0.0-0.1 ph2.9 Day 1	1132718	2.9	3.3	4.5	-	-	-	-	**300[#1]**	-	-	6.2
			BH35_0.0-0.1 ph2.9 Day 2	1132718	2.9	4.2	4.4	-	-	-	-	**240[#1]**	-	-	4.7
			BH35_0.0-0.1 ph2.9 Day 3	1132718	2.9	4.3	4.3	-	-	-	-	**65[#1]**	-	-	1.4[#1]
			BH35_0.0-0.1 ph2.9 Day 4	1132718	2.9	4.2	4.3	-	-	-	-	**65[#1]**	-	-	1.0
			BH35_0.0-0.1 ph2.9 Day 5	1132718	2.9	4.1	4.2	-	-	-	-	**42[#1]**	-	-	0.67
			BH35_0.0-0.1 ph2.9 Day 6	1132718	2.9	4.0	4.0	-	-	-	-	**43[#1]**	-	-	0.74
			BH35_0.0-0.1 ph2.9 Day 7	1132718	2.9	3.9	3.9	-	-	-	-	**49[#1]**	-	-	0.56
			BH35_0.0-0.1 ph2.9 Day 8	1132718	2.9	3.8	3.9	-	-	-	-	**40[#1]**	-	-	0.40[#1]
			BH35_0.0-0.1 ph2.9 Day 9	1132718	2.9	3.7	3.7	-	-	-	-	**21[#1]**	-	-	0.39
			BH35_0.0-0.1 ph5 Day 1	1132718	4.9	5.2	6.5	-	-	-	-	**110**	-	-	1.7
			BH35_0.0-0.1 ph5 Day 2	1132718	4.9	5.7	6.2	-	-	-	-	**110**	-	-	1.4
			BH35_0.0-0.1 ph5 Day 3	1132718	4.9	5.9	6.2	-	-	-	-	**95[#1]**	-	-	1.1[#1]
			BH35_0.0-0.1 ph5 Day 4	1132718	5.0	5.7	6.0	-	-	-	-	**110[#1]**	-	-	1.1
			BH35_0.0-0.1 ph5 Day 5	1132718	4.9	5.7	5.8	-	-	-	-	**63[#1]**	-	-	0.75
			BH35_0.0-0.1 ph5 Day 6	1132718	5.0	5.6	5.7	-	-	-	-	**83[#1]**	-	-	0.80
			BH35_0.0-0.1 ph5 Day 7	1132718	5.0	5.5	5.6	-	-	-	-	**33[#1]**	-	-	0.59
			BH35_0.0-0.1 ph5 Day 8	1132718	4.9	5.5	5.5	-	-	-	-	**30[#1]**	-	-	0.36[#1]
			BH35_0.0-0.1 ph5 Day 9	1132718	4.9	5.3	5.4	-	-	-	-	**52[#1]**	-	-	0.38[#1]
			BH35_0.0-0.1 ph5 Day 10	1132718	5.0	5.3	5.3	-	-	-	-	**24[#1]**	-	-	0.22[#1]

Field ID	PFAS - Perfluoroalkyl Carboxylic Acids: Perfluorobutanoic acid (PFBA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoDA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorooctanoic acid (PFOA)	Perfluoropentanoic acid (PFPeA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnDA)
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PFAS NEMP 2.0 2020 Freshwater - 95% (leached)							**220**				
PFAS NEMP 2.0 2020 Freshwater - 99% (leached)							19				
BH19_1.0-1.1	0.16	<0.01	<0.01	0.73[#1]	0.59	5.5[#1]	2.9[#1]	0.44	<0.01	<0.01	0.03[#1]
BH26_1.0-1.1	0.06	0.46	<0.01	0.29[#1]	0.25	0.57[#1]	0.58[#1]	0.17	<0.01	<0.01	1.7[#1]
BH27_1.0-1.1	<0.05	<0.01	<0.01	0.08[#1]	0.20	0.43[#1]	0.26[#1]	0.05	<0.01	<0.01	<0.01
BH35_0.0-0.1 ph2.9 Day 1	-	-	-	-	-	-	0.54[#1]	-	-	-	-
BH35_0.0-0.1 ph2.9 Day 2	-	-	-	-	-	-	0.44[#1]	-	-	-	-
BH35_0.0-0.1 ph2.9 Day 3	-	-	-	-	-	-	0.40[#1]	-	-	-	-
BH35_0.0-0.1 ph2.9 Day 4	-	-	-	-	-	-	0.37	-	-	-	-
BH35_0.0-0.1 ph2.9 Day 5	-	-	-	-	-	-	0.25	-	-	-	-
BH35_0.0-0.1 ph2.9 Day 6	-	-	-	-	-	-	0.28	-	-	-	-
BH35_0.0-0.1 ph2.9 Day 7	-	-	-	-	-	-	0.23	-	-	-	-
BH35_0.0-0.1 ph2.9 Day 8	-	-	-	-	-	-	0.12[#1]	-	-	-	-
BH35_0.0-0.1 ph2.9 Day 9	-	-	-	-	-	-	0.11[#1]	-	-	-	-
BH35_0.0-0.1 ph5 Day 1	-	-	-	-	-	-	0.66[#1]	-	-	-	-
BH35_0.0-0.1 ph5 Day 2	-	-	-	-	-	-	0.55[#1]	-	-	-	-
BH35_0.0-0.1 ph5 Day 3	-	-	-	-	-	-	0.28[#1]	-	-	-	-
BH35_0.0-0.1 ph5 Day 4	-	-	-	-	-	-	0.40	-	-	-	-
BH35_0.0-0.1 ph5 Day 5	-	-	-	-	-	-	0.26	-	-	-	-
BH35_0.0-0.1 ph5 Day 6	-	-	-	-	-	-	0.30	-	-	-	-
BH35_0.0-0.1 ph5 Day 7	-	-	-	-	-	-	0.25	-	-	-	-
BH35_0.0-0.1 ph5 Day 8	-	-	-	-	-	-	0.10[#1]	-	-	-	-
BH35_0.0-0.1 ph5 Day 9	-	-	-	-	-	-	0.12[#1]	-	-	-	-
BH35_0.0-0.1 ph5 Day 10	-	-	-	-	-	-	0.08[#1]	-	-	-	-

Field ID	PFAS - Perfluoroalkyl Sulfonamide: N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-Methyl perfluorooctane sulfonamidoethanol (MEFOSE)	Perfluorooctane sulfonamide (FOSA)	PFAS - Fluorotelomer: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer Sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	PFAS - Sums: PFAS (Sum of Total)	PFAS (Sum of Total)(WA DER List)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of PFHxS and PFOS	Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.01	0.05	0.01	0.1	0.05	0.01	0.01	0.01
PFAS NEMP 2.0 2020 Freshwater - 95% (leached)																
PFAS NEMP 2.0 2020 Freshwater - 99% (leached)																
BH19_1.0-1.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.01	0.95	0.06	29.65	23.46	5.4	17.5	20.4
BH26_1.0-1.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.01	0.49	0.86	16.16	13	10.08	10.28	10.86
BH27_1.0-1.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.01	<0.05	<0.01	73.85	72.13	69.26	71.5	71.76
BH35_0.0-0.1 ph2.9 Day 1	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	300.54	306.2	306.74
BH35_0.0-0.1 ph2.9 Day 2	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	240.44	244.7	245.14
BH35_0.0-0.1 ph2.9 Day 3	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	65.4	66.4	66.8
BH35_0.0-0.1 ph2.9 Day 4	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	65.37	66	66.37
BH35_0.0-0.1 ph2.9 Day 5	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	42.25	42.67	42.92
BH35_0.0-0.1 ph2.9 Day 6	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	43.28	43.74	44.02
BH35_0.0-0.1 ph2.9 Day 7	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	49.23	49.56	49.79
BH35_0.0-0.1 ph2.9 Day 8	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	40.12	40.4	40.52
BH35_0.0-0.1 ph2.9 Day 9	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	21.11	21.39	21.5
BH35_0.0-0.1 ph5 Day 1	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	110.66	111.7	112.36
BH35_0.0-0.1 ph5 Day 2	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	110.55	111.4	111.95
BH35_0.0-0.1 ph5 Day 3	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	95.28	96.1	96.38
BH35_0.0-0.1 ph5 Day 4	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	110.4	111.1	111.5
BH35_0.0-0.1 ph5 Day 5	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	63.26	63.75	64.01
BH35_0.0-0.1 ph5 Day 6	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	83.3	83.8	84.1
BH35_0.0-0.1 ph5 Day 7	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	33.25	33.59	33.84
BH35_0.0-0.1 ph5 Day 8	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	30.1	30.36	30.46
BH35_0.0-0.1 ph5 Day 9	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	52.12	52.38	52.5
BH35_0.0-0.1 ph5 Day 10	-	-	-	-	-	-	-	-	-	<0.05	-	-	-	24.08	24.22	24.3

Comments

#1 Quantification of linear and branched isomers has been conducted as a single total response using the relative response factor for the corresponding linear/branched standard.
#2 The LORs have been raised due to matrix interference

Environmental Standards

HEPA, Jan 2020, PFAS NEMP 2.0 2020 Freshwater - 95% (leached)
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Freshwater - 99% (leached)

					PFAS - Perfluoroalkyl Sulfonic Acids								PFAS - Perfluoroalkyl Carboxylic Acids										
					Perfluorobutane sulfonic acid (PFBS)	Perfluorodecanesulfonic acid (PFDS)	Perfluorononane sulfonate (PFNS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluoropropanesulfonic acid (PFPrS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)	Perfluorobutanoic acid (PFBA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoDA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorooctanoic acid (PFOA)	Perfluoropentanoic acid (PFPeA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnDA)
					µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL					0.0005	0.0005	0.001	0.0005	0.0001	0.001	0.0005	0.0005	0.002	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
NHMRC 2019 Recreational Water PFAS Guidelines																			**10**				
PFAS NEMP 2.0 2020 Freshwater - 99% - high conservation value systems									0.00023										19				
ANZG (2023) - DRAFT - PFOS DGV FW 99% Species Protection									0.0091														
PFAS NEMP 2.0 2020 Freshwater - 95% - slightly to moderately disturbed systems									**0.13**										**220**				
ANZG (2023) - DRAFT - PFOS DGV FW 95% Species Protection									*0.48*														
ANZG (2018) - FW - 95% (updated 26 July 2021)																							
Location Code	**Date**	**Field ID**	**Depth**	**Lab Report Number**																			
STMWTR_01	11 Jul 2024	STMWTR_01		1117313	0.007	<0.001	0.001	0.001[#5]	0.051	0.006	0.005[#5]	0.029[#5]	0.005	0.001	0.001	0.003[#5]	0.038[#5]	0.002	0.003[#5]	0.012	<0.001	0.002	0.008
STMWTR_02	11 Jul 2024	STMWTR_02		1117313	<0.001	<0.001	<0.001	<0.001	0.0022	<0.001	<0.001	<0.001	<0.005	0.002	<0.001	0.006	0.002[#5]	<0.001	0.002[#5]	0.022	<0.001	<0.001	<0.001
STMWTR_03	11 Jul 2024	STMWTR_03		1117313	0.001	<0.001	<0.001	<0.001	0.0040	<0.001	<0.001	0.002[#5]	<0.005	0.001	<0.001	<0.001	0.001	0.001	0.001[#5]	<0.001	<0.001	<0.001	<0.001
SW01	12 Apr 2024	SW01		1088156	0.003	<0.001	<0.001	<0.001	0.015	<0.001	0.001	0.014	0.010	<0.001	<0.001	0.005	0.011	0.002	0.009	0.013	<0.001	<0.001	<0.001
SW02	12 Apr 2024	SW02		1088156	0.003	<0.001	<0.001	<0.001	0.018	<0.001	0.001	0.014	0.008	<0.001	<0.001	0.006	0.010	0.003	0.009	0.017	<0.001	<0.001	<0.001
SW03	12 Apr 2024	QC12		1088156	0.003[#5]	<0.001	<0.001	<0.001	0.019	<0.001	0.001[#5]	0.016[#5]	<0.005	<0.001	<0.001	0.003	0.006	0.003[#5]	0.006[#5]	0.009	<0.001	<0.001	<0.001
		QC12a		EM2406055	0.0019	<0.0005	-	0.0008	0.0214	-	0.0023	0.0159	0.0083	<0.0005	<0.0005	0.0010	0.0037	0.0049	0.0043	<0.0005	<0.0005	<0.0005	<0.0005
		SW03		1088156	0.003	<0.001	<0.001	<0.001	0.017	<0.001	0.001	0.014	<0.005	<0.001	<0.001	0.005	0.008	0.003	0.007	0.006	<0.001	<0.001	<0.001
SW04	12 Apr 2024	SW04		1088156	0.002[#5]	<0.001	<0.001	<0.001	0.0042	<0.001	<0.001	0.004[#5]	0.006	<0.001	<0.001	0.004	0.008	<0.001	0.009[#5]	0.009	<0.001	<0.001	<0.001
SW05	12 Apr 2024	SW05		1088156	0.003[#5]	<0.001	<0.001	<0.001	0.0041	<0.001	<0.001	0.004[#5]	<0.005	<0.001	<0.001	0.003	0.005	<0.001	0.006[#5]	0.008	<0.001	<0.001	<0.001
SW06	12 Apr 2024	SW06		1088156	0.002[#5]	<0.001	<0.001	<0.001	0.0052	<0.001	<0.001	0.004[#5]	<0.005	<0.001	<0.001	0.003	0.005	<0.001	0.007[#5]	0.010	<0.001	<0.001	<0.001
SW07	12 Apr 2024	SW07		1088156	0.002[#5]	<0.001	<0.001	<0.001	0.0042	<0.001	<0.001	0.005[#5]	<0.005	<0.001	<0.001	0.001	0.003	<0.001	0.004[#5]	0.007	<0.001	<0.001	<0.001
SW08	11 Jul 2024	SW08		1117313	<0.001	<0.001	<0.001	<0.001	0.0025	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	0.001[#5]	0.004	<0.001	<0.001	<0.001
SW09	11 Jul 2024	SW09		1117313	<0.001	<0.001	<0.001	<0.001	0.0026	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	0.001[#5]	<0.001	0.001[#5]	0.002	<0.001	<0.001	<0.001
SW10	11 Jul 2024	SW10		1117313	0.001	<0.001	<0.001	<0.001	0.0030	<0.001	<0.001	0.001[#5]	<0.005	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001
SW11	11 Jul 2024	SW11		1117313	<0.001	<0.001	<0.001	<0.001	0.0034	<0.001	<0.001	0.001[#5]	<0.005	<0.001	<0.001	<0.001	0.002[#5]	<0.001	0.001[#5]	0.002	<0.001	<0.001	<0.001
SW12	11 Jul 2024	SW12		1117313	0.001	<0.001	<0.001	<0.001	0.0040	<0.001	<0.001	0.001[#5]	<0.005	0.001	<0.001	<0.001	0.002	<0.001	0.001[#5]	0.002	<0.001	<0.001	<0.001
SW13	11 Jul 2024	SW13		1117313	0.001	<0.001	<0.001	<0.001	0.0040	<0.001	<0.001	0.001[#5]	<0.005	<0.001	0.001	<0.001	0.002	<0.001	0.001[#5]	0.002	<0.001	<0.001	<0.001
SW14	11 Jul 2024	SW14		1117313	0.001	<0.001	<0.001	<0.001	0.0040	<0.001	<0.001	0.001[#5]	<0.005	<0.001	0.001	<0.001	0.002	<0.001	0.001[#5]	0.002	<0.001	<0.001	<0.001

		PFAS - Perfluoroalkyl Sulfonamide							PFAS - Sums				PFAS - Fluorotelomer Sulfonic Acids				PFAS - Sums
		N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-Methyl perfluorooctane sulfonamidoethanol (MEFOSE)	Perfluorooctane sulfonamide (FOSA)	PFAS (Sum of Total)	PFAS (Sum of Total)(WA DER List)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of PFHxS and PFOS	10:2 Fluorotelomer sulfonic acid (10:2 FTS)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer Sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL		0.001	0.0005	0.001	0.001	0.0005	0.001	0.0005	0.0002	0.0002	0.001	0.0002	0.001	0.001	0.001	0.001	0.001
NHMRC 2019 Recreational Water PFAS Guidelines												**2**					
PFAS NEMP 2.0 2020 Freshwater - 99% - high conservation value systems																	
ANZG (2023) - DRAFT - PFOS DGV FW 99% Species Protection																	
PFAS NEMP 2.0 2020 Freshwater - 95% - slightly to moderately disturbed systems																	
ANZG (2023) - DRAFT - PFOS DGV FW 95% Species Protection																	
ANZG (2018) - FW - 95% (updated 26 July 2021)																	
Location Code	**Field ID**																
STMWTR_01	STMWTR_01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.187	0.159	0.054	0.08	0.001	<0.001	0.007	0.004	0.083
STMWTR_02	STMWTR_02	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0362	0.0342	0.0042	0.0022	<0.001	<0.001	<0.005	<0.001	0.0042
STMWTR_03	STMWTR_03	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.011	0.009	0.005	0.006	<0.001	<0.001	<0.005	<0.001	0.007
SW01	SW01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.083	0.08	0.024	0.029	<0.001	<0.001	<0.005	<0.001	0.038
SW02	SW02	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.089	0.085	0.027	0.032	<0.001	<0.001	<0.005	<0.001	0.041
SW03	QC12	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.066	0.062	0.025	0.035	<0.001	<0.001	<0.005	<0.001	0.041
	QC12a	<0.001	<0.0005	<0.001	<0.001	<0.0005	<0.001	<0.0005	0.0645	0.0565	-	0.0373	<0.001	<0.001	<0.001	<0.001	-
	SW03	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.064	0.06	0.024	0.031	<0.001	<0.001	<0.005	<0.001	0.038
SW04	SW04	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0462	0.0462	0.0132	0.0082	<0.001	<0.001	<0.005	<0.001	0.0172
SW05	SW05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0331	0.0331	0.0101	0.0081	<0.001	<0.001	<0.005	<0.001	0.0141
SW06	SW06	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0362	0.0362	0.0122	0.0092	<0.001	<0.001	<0.005	<0.001	0.0162
SW07	SW07	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0262	0.0262	0.0082	0.0092	<0.001	<0.001	<0.005	<0.001	0.0132
SW08	SW08	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0075	0.0075	0.0035	0.0025	<0.001	<0.001	<0.005	<0.001	0.0035
SW09	SW09	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0066	0.0066	0.0036	0.0026	<0.001	<0.001	<0.005	<0.001	0.0036
SW10	SW10	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	0.008	0.004	0.004	<0.001	<0.001	<0.005	<0.001	0.005
SW11	SW11	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0094	0.0094	0.0044	0.0044	<0.001	<0.001	<0.005	<0.001	0.0054
SW12	SW12	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012	0.011	0.005	0.005	<0.001	<0.001	<0.005	<0.001	0.006
SW13	SW13	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012	0.011	0.005	0.005	<0.001	<0.001	<0.005	<0.001	0.006
SW14	SW14	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012	0.011	0.005	0.005	<0.001	<0.001	<0.005	<0.001	0.006

* A Non Detect Multiplier of 0.5 has been applied.

Comments

#1 Measured as NH3-N at pH 8
#2 Values taken from "Updating nitrate toxicity effects on freshwater aquatic species, 2013"
#5 Quantification of linear and branched isomers has been conducted as a single total response using the relative response factor for the corresponding linear/branched standard.

Environmental Standards

HEPA, January 2020, PFAS NEMP 2.0 2020 Freshwater - 99% - high conservation value systems
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Freshwater - 95% - slightly to moderately disturbed systems
Department of Agriculture and Water Resources, 2018 updated July 2021, ANZG (2018) - FW - 95% (updated 26 July 2021)

Location Code	Date	Field ID	Depth	Lab Report Number	Nutrients								Metals																							
					Ammonia as N	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised) (as N)	Nitrogen (Total)	Kjeldahl Nitrogen Total	Nitrogen (Organic)	Phosphorus (Total)	Arsenic	Arsenic (filtered)	Cadmium	Cadmium (filtered)	Chromium (III+VI)	Chromium (III+VI) (filtered)	Copper	Copper (filtered)	Lead	Lead (filtered)	Mercury	Mercury (filtered)	Molybdenum	Molybdenum (filtered)	Nickel	Nickel (filtered)	Selenium	Selenium (filtered)	Silver	Silver (filtered)	Tin	Tin (filtered)	Zinc	Zinc (filtered)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL					0.01	0.02	0.02	0.05	0.2	0.2	0.2	0.01	0.001	0.001	0.0001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.0001	0.0001	0.005	0.005	0.001	0.001	0.001	0.001	0.005	0.005	0.005	0.005	0.005	0.005
NHMRC 2019 Recreational Water PFAS Guidelines																																				
PFAS NEMP 2.0 2020 Freshwater - 99% - high conservation value systems																																				
ANZG (2023) - DRAFT - PFOS DGV FW 99% Species Protection																																				
PFAS NEMP 2.0 2020 Freshwater - 95% - slightly to moderately disturbed systems																																				
ANZG (2023) - DRAFT - PFOS DGV FW 95% Species Protection																																				
ANZG (2018) - FW - 95% (updated 26 July 2021)					0.9[#1]	2.4[#2]								0.013[#3]		0.0002		0.001[#4]		0.0014		0.0034		0.0006				0.011		0.011		0.00005				0.008
STMWTR_01	11 Jul 2024	STMWTR_01		1117313	<0.01	0.06	<0.02	-	-	-	-	-	-	<0.001	-	<0.0002	-	<0.001	-	0.006	-	0.002	-	<0.0001	-	-	-	<0.001	-	-	-	-	-	-	-	0.053
STMWTR_02	11 Jul 2024	STMWTR_02		1117313	0.09	0.24	0.07	-	-	-	-	-	-	<0.001	-	<0.0002	-	0.001	-	0.016	-	0.009	-	<0.0001	-	-	-	0.001	-	-	-	-	-	-	-	0.12
STMWTR_03	11 Jul 2024	STMWTR_03		1117313	0.02	0.18	<0.02	-	-	-	-	-	-	<0.001	-	<0.0002	-	<0.001	-	0.004	-	0.002	-	<0.0001	-	-	-	<0.001	-	-	-	-	-	-	-	0.11
SW01	12 Apr 2024	SW01		1088156	0.24	1.8	<0.02	1.8	2.3	0.5	0.26	0.16	0.001	-	<0.0002	-	<0.001	-	0.002	-	0.001	-	<0.0001	-	<0.005	-	<0.001	-	0.003	-	<0.005	-	<0.005	-	0.007	-
SW02	12 Apr 2024	SW02		1088156	0.26	1.7	<0.02	1.7	2.7	1.0	0.74	0.24	0.001	-	<0.0002	-	0.001	-	0.002	-	0.002	-	<0.0001	-	<0.005	-	0.001	-	0.003	-	<0.005	-	<0.005	-	0.010	-
SW03	12 Apr 2024	QC12		1088156	0.14	0.42	<0.02	0.42	2.3	1.9	1.76	0.15	-	<0.001	-	<0.0002	-	<0.001	-	<0.001	-	<0.001	-	<0.0001	-	<0.005	-	<0.001	-	0.003	-	<0.005	-	<0.005	-	<0.005
		QC12a		EM2406055	-	-	-	-	-	-	-	-	-	<0.001	-	<0.0001	-	<0.001	-	0.002	-	0.001	-	<0.0001	-	-	-	<0.001	-	-	-	-	-	-	-	0.015
		SW03		1088156	0.12	1.7	<0.02	1.8	3.0	1.2	1.08	0.17	<0.001	-	<0.0002	-	<0.001	-	0.002	-	0.001	-	<0.0001	-	<0.005	-	<0.001	-	0.004	-	<0.005	-	<0.005	-	0.010	-
SW04	12 Apr 2024	SW04		1088156	1.3	1.8	<0.02	1.8	3.3	1.5	0.2	0.04	0.001	-	<0.0002	-	<0.001	-	0.001	-	<0.001	-	<0.0001	-	<0.005	-	<0.001	-	0.004	-	<0.005	-	<0.005	-	0.007	-
SW05	12 Apr 2024	SW05		1088156	0.60	0.97	<0.02	0.97	2.1	1.1	0.5	0.06	0.001	-	<0.0002	-	<0.001	-	0.002	-	0.001	-	<0.0001	-	<0.005	-	<0.001	-	0.004	-	<0.005	-	<0.005	-	0.009	-
SW06	12 Apr 2024	SW06		1088156	0.17	1.1	<0.02	1.1	2.1	1.0	0.83	0.09	0.002	-	<0.0002	-	0.001	-	0.003	-	0.004	-	<0.0001	-	<0.005	-	0.002	-	0.004	-	<0.005	-	<0.005	-	0.034	-
SW07	12 Apr 2024	SW07		1088156	0.12	1.1	<0.02	1.1	3.0	1.9	1.78	0.26	0.001	-	<0.0002	-	<0.001	-	0.001	-	0.002	-	<0.0001	-	<0.005	-	0.001	-	0.003	-	<0.005	-	<0.005	-	0.016	-
SW08	11 Jul 2024	SW08		1117313	0.04	0.61	0.30	-	-	-	-	-	-	<0.001	-	<0.0002	-	0.002	-	0.003	-	0.002	-	<0.0001	-	-	-	<0.001	-	-	-	-	-	-	-	0.027
SW09	11 Jul 2024	SW09		1117313	0.03	0.34	<0.02	-	-	-	-	-	-	<0.001	-	<0.0002	-	0.003	-	0.003	-	0.005	-	<0.0001	-	-	-	<0.001	-	-	-	-	-	-	-	0.031
SW10	11 Jul 2024	SW10		1117313	<0.01	0.18	<0.02	-	-	-	-	-	-	<0.001	-	<0.0002	-	0.002	-	0.003	-	0.002	-	<0.0001	-	-	-	<0.001	-	-	-	-	-	-	-	0.031
SW11	11 Jul 2024	SW11		1117313	0.04	0.11	<0.02	-	-	-	-	-	-	<0.001	-	<0.0002	-	0.002	-	0.004	-	0.003	-	<0.0001	-	-	-	0.001	-	-	-	-	-	-	-	0.046
SW12	11 Jul 2024	SW12		1117313	0.10	0.38	<0.02	-	-	-	-	-	-	<0.001	-	<0.0002	-	0.002	-	0.004	-	0.003	-	<0.0001	-	-	-	0.001	-	-	-	-	-	-	-	0.039
SW13	11 Jul 2024	SW13		1117313	0.05	0.20	<0.02	-	-	-	-	-	-	0.001	-	<0.0002	-	0.002	-	0.004	-	0.003	-	<0.0001	-	-	-	0.001	-	-	-	-	-	-	-	0.033
SW14	11 Jul 2024	SW14		1117313	<0.01	0.37	0.10	-	-	-	-	-	-	<0.001	-	<0.0002	-	0.002	-	0.004	-	0.003	-	<0.0001	-	-	-	0.001	-	-	-	-	-	-	-	0.034

* A Non Detect Multiplier of 0.5 has been applied.

Comments

#1 Measured as NH3-N at pH 8
#2 Values taken from "Updating nitrate toxicity effects on freshwater aquatic species, 2013"
#5 Quantification of linear and branched isomers has been conducted as a single total response using the relative response factor for the

Environmental Standards

HEPA, January 2020, PFAS NEMP 2.0 2020 Freshwater - 99% - high conservation value systems
HEPA, Jan 2020, PFAS NEMP 2.0 2020 Freshwater - 95% - slightly to moderately disturbed systems
Department of Agriculture and Water Resources, 2018 updated July 2021, ANZG (2018) - FW - 95% (updated 26 July 2021)

Location Code	Date	Field ID	Lab Report Number	PFAS - Perfluoroalkyl Sulfonic Acids								PFAS - Perfluoroalkyl Carboxylic Acids										
				Perfluorobutane sulfonic acid (PFBS)	Perfluorodecanesulfonic acid (PFDS)	Perfluorononane sulfonate (PFNS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluoropropanesulfonic acid (PFPrS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)	Perfluorobutanoic acid (PFBA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoDA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorooctanoic acid (PFOA)	Perfluoropentanoic acid (PFPeA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnDA)
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL				0.0002	0.0002	0.005	0.0002	0.0002	0.005	0.0002	0.0002	0.001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0002	0.0002
PFAS NEMP 2.0 2020 Public open space (HIL C)								1			1							10				
SED01	12 Apr 2024	SED01	1088156	<0.005	<0.005	<0.005	<0.005	0.0059	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
SED02	12 Apr 2024	SED02	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
SED03	12 Apr 2024	QC12	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
		QC12a	EM2406055	<0.0002	<0.0002	-	<0.0002	<0.0002	-	<0.0002	<0.0002	<0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	<0.0002	<0.0002
		SED03	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
SED04	12 Apr 2024	SED04	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
SED05	12 Apr 2024	SED05	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005#1	<0.005	<0.005	<0.005	<0.005	<0.005
SED06	12 Apr 2024	SED06	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
SED07	12 Apr 2024	SED07	1088156	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Location Code	Date	Field ID	Lab Report Number	PFAS - Perfluoroalkyl Sulfonamide							PFAS - Fluorotelomer Sulfonic Acids				PFAS - Sums			
				N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-Methyl perfluorooctane sulfonamidoethanol (MEFOSE)	Perfluorooctane sulfonamide (FOSA)	10:2 Fluorotelomer sulfonic acid (10:2 FTS)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer Sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	PFAS (Sum of Total)	PFAS (Sum of Total)(WA DER List)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of PFHxS and PFOS
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL				0.0005	0.0002	0.0005	0.0005	0.0002	0.0005	0.0002	0.0005	0.0005	0.0005	0.0005	0.0002	0.0002	0.005	0.0002
PFAS NEMP 2.0 2020 Public open space (HIL C)																		1
SED01	12 Apr 2024	SED01	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	0.0059	0.0059
SED02	12 Apr 2024	SED02	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005
SED03	12 Apr 2024	QC12	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005
		QC12a	EM2406055	<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005	<0.0002	<0.0002	-	<0.0002
		SED03	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005
SED04	12 Apr 2024	SED04	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005
SED05	12 Apr 2024	SED05	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005
SED06	12 Apr 2024	SED06	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005
SED07	12 Apr 2024	SED07	1088156	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.05	<0.01	<0.005	<0.005

Comments

#1 Quantification of linear and branched isomers has been conducted as a single total response using the relative response factor for the corresponding linear/branched standard.

Environmental Standards

HEPA, Jan 2020, PFAS NEMP 2.0 2020 Public open space (HIL C)

Location Code	Date	Field ID	Lab Report Number	% Moisture_	Moisture (%)	Ammonia as N	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised) (as N)	Nitrogen (Total)	Kjeldahl Nitrogen Total	Nitrogen (Organic)	Phosphorus (Total)	Arsenic	Cadmium	Chromium (III+VI)	Copper	Lead	Mercury	Molybdenum	Nickel	Selenium	Silver	Tin	Zinc	Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*
				Misc.	Inorganics	Nutrients								Metals												PFAS - Sums
				%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL				1	0.1	5	5	5	5	10	10	10	5	2	0.4	5	5	5	0.1	5	5	2	2	10	5	0.005
PFAS NEMP 2.0 2020 Public open space (HIL C)																										
SED01	12 Apr 2024	SED01	1088156	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0059
SED02	12 Apr 2024	SED02	1088156	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.005
SED03	12 Apr 2024	QC12	1088156	18	-	38	<5	<5	<5	110	110	72	900	2.8	<0.4	8.0	5.4	39	0.3	<5	<5	<2	<2	<10	29	<0.005
		QC12a	EM2406055	-	17.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		SED03	1088156	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.005
SED04	12 Apr 2024	SED04	1088156	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.005
SED05	12 Apr 2024	SED05	1088156	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.005
SED06	12 Apr 2024	SED06	1088156	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.005
SED07	12 Apr 2024	SED07	1088156	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.005

Comments

#1 Quantification of linear and branched isomers has been conducted as a single total response using the relative r

Environmental Standards

HEPA, Jan 2020, PFAS NEMP 2.0 2020 Public open space (HIL C)

				PFAS - Perfluoroalkyl Sulfonic Acids	PFAS - Perfluoroalkyl Carboxylic Acids	PFAS - Fluorotelomer Sulfonic Acids		PFAS - Sums		Surrogate					PFAS
				Perfluorooctane sulfonic acid (PFOS)	Perfluorooctanoic acid (PFOA)	6:2 Fluorotelomer Sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	Sum of US EPA PFAS (PFOS + PFOA)*	Sum of PFHxS and PFOS	13C2-6:2 FTS (surr.)	13C2-8:2 FTS (surr.)	13C4-PFOS	18O2-PFHxS (surr.)	Extracted ISTD 13C4 PFOA	Perfluorohexane sulfonate
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	%	%	%	%	mg/kg
EQL				0.001	0.001	0.001	0.001	0.001	0.001						0.001
Location Code	**Date**	**Field ID**	**Lab Report Number**												
Apricot Tree	21 Jan 2019	Christie_Apricot	210445	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	86	96	88	83	86	<0.001
Lime Tree	21 Jan 2019	Christie_Lime	210445	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0[#1]	103	102	89	109	0.001

Comments
#1 Recovery not available. Please see the PDF report for details

Appendix C

Toxicity assessment supplementary information

C-1 Introduction

A toxicity assessment determines whether human exposure to a chemical could cause an increase in the incidence of an adverse health condition (NEPC, 1999). The outcomes of the toxicity assessment process are a set of toxicity criteria that are compared with exposure estimates to evaluate risk associated with chemical exposure pathways.

In accordance with the ASC NEPM (NEPC, 1999) Schedule B4, the toxicity assessment for this HHRA includes two elements:

1. *Hazard Identification*, which examines the capacity of PFOS+PFHxS to cause adverse health effects.
2. *Dose Response assessment*, which examines the quantitative relationships between PFOS+PFHxS exposure and health effects, to determine the levels of exposure that could give rise to adverse effects.

Reference has been made primarily to the toxicological information published by FSANZ (2017) which was used to establish the current Australian guidelines for PFOS, PFOA, and PFHxS, as published in the PFAS NEMP (HEPA, 2020). Consideration has also been given to pertinent information from the following sources:

– US Agency for Toxic Substances and Disease Registry (ATSDR)
– International Agency for Research on Cancer (IARC)
– European Food Safety Authority (EFSA)
– US Environmental Protection Agency (EPA)
– World Health Organization (WHO)
– Published scientific literature.

C-2 Hazard identification

Numerous studies have been undertaken into the possible health effects of PFAS in humans. Most human studies attempt to identify a relationship between levels of PFAS in the blood and a health effect but results to date (at the time of preparing this HHRA) have been inconsistent. Additional difficulties arise when seeking to extrapolate from animal to human studies, as humans and animals have been found to react differently to exposure to PFOS and PFOA, with profound differences in the toxicokinetics and toxicodynamics observed (ATSDR, 2021).

C-2-1 Acute toxicity

Acute exposures are typically defined as those occurring over a period of 14 days or less. Contaminated land risk assessments generally focus on chronic effects, but acute effects can be important in some circumstances and should not be ignored in hazard identification process.

The limited data available for humans has not identified acute toxicity associated with exposure to PFOS or PFHxS through inhalation, ingestion, dermal or ocular contact (ATSDR, 2021). Acute toxicity is, therefore, unlikely to be associated with exposure to the PFAS concentration measured in soil collected from within the Investigation Area and acute exposures have not been considered further in this HHRA.

C-2-2 Chronic toxicity – animal studies

Animal studies have indicated that chronic exposure of PFOS in mice, rats and monkeys can result in increased liver weight, liver cell hypertrophy, histopathological changes to lungs, decreased hormone levels and immunotoxicity (Bae et al., 2015). Reproductive and developmental toxicity have also been observed in animal studies, but generally at doses similar or only marginally lower than that which also produced maternal toxicity (ATSDR, 2021; EFSA, 2020; FSANZ, 2017). EFSA (2020) concluded that PFOS has been shown to cause a reduced response to vaccination (T-cell dependent antibody response) at doses where no other toxicity was evident.

Limited animal studies have indicated that chronic exposure to PFHxS in rats can result in increased liver weights, histopathological changes to lungs and thyroid glands and haematological effects (Butenhoff et al., 2009). The predominant effects identified for PFOA in rodents have also been adverse effects on the liver, via a mechanism that FSANZ (2017) does not consider relevant to humans. Other effects of PFOA in animal studies include effects on body and organ weights, immunotoxicity and hypoglycaemia (FSANZ, 2017). Similarly, to PFOS, reproductive and developmental toxicity, including decreased offspring weights and neurodevelopmental effects have also been observed in animal studies for PFOA at doses lower than those associated with maternal toxicity (ATSDR, 2021; FSANZ, 2017).

Limited data is available to evaluate the toxicity of many of the other individual PFAS compounds, but ATSDR (2021) and EFSA (2020) identified animal toxicological studies on perfluoroalkyl carboxylates (PFCAs) – e.g., perfluorohexanoic acid (PFHxA), perfluorobutanoic acid (PFBA), and perfluoroheptanoic acid (PFHpA) – perfluoroalkyl sulfonates (PFSAs) including perfluorobutane sulfonic acid (PFBS), perfluorononanoic acid (PFNA) and perfluorooctane sulfonamide (FOSA) and the US EPA (2023a) has published drinking water standards for PFHxS, PFNA and PFBS. The toxic effects of compounds other than PFOS have generally been identified in animal studies undertaken on these compounds at doses several orders of magnitude higher than for PFOS and PFOA, but the dataset for these other compounds is limited (EFSA, 2020; ATSDR, 2021).

The most consistent endpoint identified in the studies undertaken on other PFAS compounds were liver weight effects, disturbances in lipid metabolism and hepatotoxic effects. Many PFAS also decreased the levels of thyroid hormones and some compounds increased relative kidney weight (EFSA, 2020; ATSDR, 2021). Developmental toxicity studies identified for a subset of these other PFAS compounds identified increased fetal and/or neonatal mortality and reduction in fetal weight and/or postnatal growth, at similar or slightly lower doses than those exerting maternal toxicity. Effects on male reproductive parameters have also been reported for PFCAs including PFNA and PFDA and immune system effects have been identified for PFNA and PFDA (EFSA, 2020; ATSDR, 2021).

C-2-3 Chronic toxicity – epidemiological studies

Epidemiological studies typically involve the analysis of associations between PFAS exposure (e.g., concentrations in environmental matrices and humans) and human diseases and health endpoints.

The Australian Government commissioned an independent Expert Health Panel to identify potential health impacts associated with PFAS exposure and to identify priority areas for further research (Buckley et al., 2017). This panel found that scientific research indicated consistent links between human exposure to PFAS and the following adverse health outcomes:

- Increased levels of cholesterol in the blood
- Increased levels of uric acid in the blood
- Reduced kidney function
- Alterations in some indicators of immune response
- Altered levels of thyroid hormones and sex hormones
- Later age for starting menstruation in girls and earlier menopause in women
- Lower birth weight in babies.

Notably, the differences in health effects reported in the scientific literature between people who have experienced high and low levels of PFAS exposure were generally small, with the health of the people with the highest exposure generally still within normal ranges for the general population. The Panel concluded that "*there is mostly limited or no evidence for any link with human disease*". These conclusions are generally consistent with those reported by FSANZ (2017) for epidemiological studies.

In a recent review undertaken by EFSA (2020) it was concluded that epidemiological studies provide evidence for an association between exposure to PFAS and increased serum levels of cholesterol. Associations between PFAS exposure and increased serum levels of the liver enzymes were also identified but the magnitude of these associations was small (~3%) and there were no associations identified with liver disease. EFSA (2020) also concluded that epidemiological studies provide insufficient evidence of associations between PFAS exposure and reproductive outcomes, neurodevelopment outcomes, growth in infancy or childhood, neurobehavioral, neuropsychiatric, cognitive outcomes, thyroid function, changes in kidney function or serum levels of uric acid.

In 2021, the Society of Environmental Toxicology and Chemistry (SETAC) convened a review of the health risks associated with exposure to PFAS. Overall, it was concluded that, based on animal studies and the available epidemiological data that there was strong evidence that the following were sensitive toxicity endpoints for human exposure to PFAS:

– Suppression of immune response
– Alteration of thyroid hormones
– Disruption of liver metabolism
– Reproductive and developmental effects (Fenton, et al., 2021)

Overall, all the reviewing bodies identified that there was limited epidemiological information available for compounds other than PFOS and PFOA.

C-2-4 Carcinogenicity

In December 2023, the International Agency for Research on Cancer (IARC), the cancer agency of the World Health Organization (WHO), evaluated the carcinogenicity of PFOA and PFOS. The classifications derived can be summarised as follows:

– The IARC classified PFOA as *carcinogenic to humans* (Group 1) on the basis of sufficient evidence for cancer in experimental animals and strong mechanistic evidence (for epigenetic alterations and immunosuppression) in exposed humans. There was also limited evidence for cancer in humans (renal cell carcinoma and testicular cancer) and strong mechanistic evidence in human primary cells and experimental systems (for epigenetic alterations and immunosuppression, as well as several other key characteristics of carcinogens).
– The IARC classified PFOS as *possibly carcinogenic to humans* (Group 2B), on the basis of strong mechanistic evidence across test systems, including in exposed humans (for epigenetic alterations and immunosuppression, as well as several other key characteristics of carcinogens). There was also limited evidence for cancer in experimental animals and inadequate evidence regarding cancer in humans.

At the time of reporting the classification document had not been published by the IARC but a summary of the classification was documented by Zahm *et al.* (2024). The US EPA (2023a) has recently reviewed the available human epidemiological and animal toxicity studies and concluded that a classification of "*Likely to Be Carcinogenic to Humans*" is applicable, as "*the weight of evidence is sufficient to demonstrate carcinogenic potential to humans but does not reach the weight of evidence for the descriptor 'Carcinogenic to Humans'*". The details of this classification can be summarised as follows:

– The PFOS classification is primarily based several epidemiological studies that report an elevated risk of bladder, prostate, kidney, and breast cancers after chronic PFOS exposure. The detailed review undertaken by US EPA (2024), however, concluded that the study designs, analyses, and mixed results do not allow for a definitive conclusion on the relationship between PFOS exposure and cancer outcomes in humans. A single chronic animal cancer bioassay was identified to support the classification, whereby tumorigenesis was identified in male and female rats. This study was the same study referenced in the reviews undertaken by EFSA (2020) and FSANZ (2017).
– The PFOA classification is based on the evidence of kidney and testicular cancer in humans and pancreatic and kidney tumours in rats. The detailed review undertaken by US EPA (2023b) concluded that PFOA may act through multiple carcinogenic modes of action.
– The risks associated with exposure to potentially carcinogenic compounds can be assessed as follows:
  - *Non-threshold toxicity*: For genotoxic carcinogens there is no evidence of a threshold level of exposure for carcinogenicity. These compounds are assessed using a non-threshold approach, whereby it is assumed that there is a proportional relationship between dose and carcinogenicity at low concentrations
  - *Threshold toxicity*: For non-genotoxic carcinogens, there is a level of exposure, below which there is no appreciable cancer risk. These compounds are assessed using a threshold approach, whereby it is assumed that there is unlikely to be an appreciable risk of deleterious carcinogenic effects during a lifetime at concentrations below an adopted TRV.

EFSA (2020) and FSANZ (2017) reviewed the weight of evidence from *in vitro* and *in vivo* genotoxicity studies, and concluded that the toxicity of PFOS and PFOA occurs through non-genotoxic threshold mechanisms. The ATSDR (2021) and EFSA (2020) also noted that human epidemiology studies did not find a consistent correlation between PFOS exposure and cancer incidence in occupational and general population studies. Hence, the EFSA (2020) FSANZ (2017) adopt a threshold approach to the assessment of PFAS exposure (i.e. the use of threshold TRV). Conversely, the US EPA (2023a) has assumed low dose linearity for both PFOS and PFOA (i.e., a non-threshold to dose response assessment) as a conservative approach, is an absence of definitive information supporting a single, scientifically justified mode of action.

At the time of reporting, FSANZ maintain the stance that available toxicological information on PFAS suggests threshold toxicity as opposed to non-threshold toxicity. As such, a threshold approach has been adopted in this HHRA for the PFAS dose response assessment, in line with the approach adopted by FSANZ (2017) and other international jurisdictions.

C-2-5 Toxicokinetics

Gastrointestinal absorption

In animal studies, PFOS and PFOA are rapidly and virtually completely absorbed (>95%) through the gastrointestinal tract. The limited data that is available for PFHxS also suggests rapid and virtually complete (>95%) gastrointestinal absorption (FSANZ, 2017). Similar patterns of gastrointestinal absorption have been reported for other PFSAs, including PFHxS, and for PFCAs including PFHxA, PFBA and PFHpA (EFSA, 2020). On this basis, it has been assumed that 100% of PFAS in water matrices (e.g., surface water and groundwater) may be absorbed into the gastrointestinal tract.

Dermal absorption

The functional groups of some PFAS compounds can dissociate into anions or cations in aqueous solution, depending upon pH. Due to their low acid dissociation constants, PFAS compounds such as PFOS and PFOA are predominantly present in a dissociated state in the aqueous phase, under typical environmental conditions (ITRC, 2022). The dermal permeability of chemicals is influenced by the state of ionization, with non-ionized forms of chemicals being more readily absorbed than the dissociated forms (US EPA, 2004). Hence, although limited data is available regarding the propensity of PFAS to be absorbed through the skin, it is expected that, under normal conditions, the dermal absorption of these compounds is negligible.

In two studies cited by ATSDR (2021) and EFSA (2020), 0.05% of the dose of PFOA applied to skin was absorbed under normal conditions. The estimated dermal penetration coefficients from these studies were approximately $1x10^{-6}$ centimetres per hour (cm/hour) (Fasano et al., 2005) and $4.4x10^{-5}$ cm/hr (Franko et al., 2012), with the latter value estimated for PFOA dissolved in acetone and for skin pre-treated with glycerol, both of which may have enhanced PFOA absorption.

While dermal permeability data was not identified for PFOS, the dermal permeability of this compound is also expected to be low under normal environmental and skin conditions.

Distribution, metabolism, and elimination

Following absorption, PFAS are widely distributed in the body, with the highest concentrations generally found in the liver, kidneys, and blood. However, the distribution pattern depends on the compound, species, and administration dose/route. PFAS can also be transferred to the foetus during pregnancy and to nursing infants during breastfeeding. In vivo and in vitro studies suggest that PFSA and PFCA are not metabolised within the body (ATSDR, 2021).

Elimination of PFAS occurs primarily in the urine. The elimination rates (half-lives) vary widely across animal species and even between sexes of the same species, and among PFAAs with different functional groups and carbon chain lengths. In humans, the estimated half-lives for short-chain PFAS (such as PFBA and PFHxA) range from a few days to approximately one month, whereas for compounds with a long perfluoroalkyl chain length (such as PFOA, PFHxS or PFOS), it can be several years (EFSA, 2020). The estimated range of half-lives for elimination of PFOA, PFOS and PFHxS, as presented by Pizurro *et al.* (2019) are 2.3 to 8.5 years, 3.3 to 5.4 years and 5.3 to 15.5 years respectively.

C-3 Dose response assessment

As discussed in Section C-2-4, this HHRA focuses on potential threshold risks linked to PFAS exposure. The hazard identification process (Section C-2) suggests that PFAS has relatively low acute toxicity following oral and dermal exposures and that dermal uptake is negligible. The focus of this HHRA is, therefore, the potential chronic PFAS exposures that may occur in association with oral exposure to PFOS and PFHxS.

Chronic health risks are assessed by comparing the estimated intake doses with toxicity reference values (TRVs). For threshold chemicals, TRVs are a measure of tolerable daily exposure and include values that are referenced by different agencies using a range of terms, including acceptable daily intake (ADI), tolerable daily intake (TDI), reference dose (RfD) or minimal risk level (MRL).

These values estimate the daily dose of a chemical to the human population (including sensitive subpopulations) that is likely to be without risk of deleterious non-cancer effects during a lifetime. TRVs for PFOS+PFHxS are typically expressed in ng/kg of body weight/day.

The derivation of TRVs is a two-step process:

1. Defining a point of departure (POD)
2. Extrapolating from the POD for relevance to human exposure.

For threshold compounds the POD for the dose response assessment is typically the no-observed-adverse-effect level (NOAEL) or lowest-observed-adverse-effect level (LOAEL) derived from relevant animal or human data. To derive the TRVs for threshold health effects, the POD is typically adjusted downwards (i.e., made more conservative) to account for the uncertainty that is associated with extrapolation from experimental animals to humans and to account for the variability in the health responses of individuals. Downwards adjustments are also made to the POD in response to limitations in the available toxicological dataset (e.g., limited study durations or the absence of studies addressing specific potential endpoints) and when the POD is a LOAEL rather than a NOAEL. The adjustments are made using uncertainty factors (UF) of up to 10 for each potential source of uncertainty.

C-3-1 TRVs adopted in this HHRA – PFOS and PFHxS

FSANZ (2017) developed TRVs for oral exposure to PFOS+PFHxS, based upon the results of laboratory animal studies, with uncertainty factors applied to account for interspecies differences in toxicodynamics and differences between human populations. Due to the variability in half lives of PFOS by species, a pharmacokinetic modelling approach was used in conjunction with the NOAELs derived in animal studies to derive the following TRVs:

– For PFOS, FSANZ has recommended a TRV of 20 ng/kg bw/day based on decreased parental and offspring body weight gains in a multigeneration reproductive toxicity study in rats. The TRV was derived by applying pharmacokinetic modelling to the serum PFOS concentrations measured in experimental animals at the NOAELs in these and other critical studies, to calculate human equivalent doses (HED). An uncertainty factor of 30 was applied to the HED, which comprised a default factor of 3 to account for interspecies differences in toxicodynamics and a default factor of 10 for intraspecies differences in the human population.
– For PFHxS, there was insufficient toxicological and epidemiological information to derive a TRV. In the absence of a TRV, it is reasonable to conclude that the enHealth (2016) approach of using the TRV for PFOS is likely to be conservative and protective of public health as an interim measure. Effectively, this means that PFHxS and PFOS should be summed for the purposes of a dietary exposure assessment and risk characterisation. This is in line with the HHERA approach.

The FSANZ (2017) TRV adopted in this HHRA is detailed in Table C-1. This TRV is also recommended in the PFAS NEMP.

Table C-1 Summary of Toxicity Reference Values (FSANZ, 2017)

Chemical	Toxicity Reference Values
PFOS, PFHxS (sum)	20 ng/kg/day

C-3-2 Dose response uncertainties

A variety of international jurisdictions have assessed the toxicity of PFOS and PFHxS and published TRVs. The TRVs established for PFOS and PFHxS by EFSA (2020) and proposed (currently draft for public comment) by the US EPA (2024) are lower than the values recommended by FSANZ (2017), suggesting that there is still controversy about PFAS and associated human health risk. The primary difference between the PFOS+PFHxS TRV derived by FSANZ (2017) and the values proposed by these other international agencies, is the approach used to incorporate immunotoxicity, as follows:

– The TRV adopted by EFSA (2020) (0.63 ng/kg/day, applicable to the sum of PFOS, PFHxS, PFOA and PFNA) is based on two human epidemiological studies. A study with children on the Faroe Islands showed various associations between the serum levels of individual PFAS and the sum of these four compounds and antibody responses against diphtheria and tetanus vaccinations (Grandjean et al., 2012). In addition, a more recent study on children from Germany (Abraham et al., 2020) showed an inverse association between serum levels of the sum of PFOA, PFNA, PFHxS and PFOS, and antibody responses against haemophilus influenzae type b, diphtheria, and tetanus in 1-year-old predominantly breastfed children.
– The TRV proposed by US EPA (2024) (0.0079 ng/kg/day for PFOS alone) is based on the same Grandjean et al. (2012) as referenced by EFSA (2020). The primary difference between the two values relates to the application by US EPA (2024) of an uncertainty factor of 10 to account for the potential for human variability. This was not deemed to be required by EFSA (2020) on the basis that the toxicity endpoint was a vaccine response (i.e., a possible reduction in disease prevention), rather than the direct measurement of the development of a disease. The TRVs also differed because the endpoint adopted by the US EPA (2024) corresponded to the 95% lower confidence limit of a 5% change in antibody response, whereas the EFSA (2020) toxicity endpoint adopted a less conservative 10% change.
– The US EPA (2024) has also proposed (but not officially adopted) a Maximum Contaminant Level (MCL) drinking water guidelines for PFOS and PFHxS of 4 ng/L individually. These MCLs represent the levels at which they can be reliably measured in drinking water, with the goal being an absence of PFOS and PFOA in drinking water.
– FSANZ (2017) acknowledged the potential immunotoxicity associated with exposure to PFOS, noting that there are both positive and negative studies showing associations for increasing PFOS concentrations to compromise antibody production in humans. Based on a review of the available studies undertaken by Drew and Hagen (2016) however, FSANZ (2017) concluded that PFOS effects on vaccine response are weak and not consistent for all vaccines. FSANZ (2017) also concluded that there is no convincing evidence for increased incidence of infectious disease associated with PFOS effects on human immune function, as the epidemiological studies that have observed decreased antibody response have not found significant increases in infection rates. In particular, Drew and Hagen (2016) noted that the NOAEL serum PFAS concentrations derived by Grandjean *et al.* (2012) are very low and that a number of environmental pollutants (e.g., polychlorinated biphenyls and mercury) could have been associated with altered levels of various antibodies in children.
– FSANZ[3] has undertaken a review of recent studies concerning the potential of PFAS to affect the human immune system. The review evaluated the relationship between PFAS and immune response to vaccinations, susceptibility to infections, and hypersensitivity responses, including allergy. The review concluded that new epidemiological studies provide some evidence of statistical associations between PFAS blood levels and impaired vaccine response, increased susceptibility to infectious disease and hypersensitivity responses but that causal relationships could not be established. At the time of reporting, based on this review, FSANZ did not consider immunomodulation as a suitable critical endpoint for quantitative risk assessment for PFAS.

Overall, the approach adopted by FSANZ to the potential immunotoxicity of PFOS+ PFHxS is more pragmatic than that recently adopted by EFSA and US EPA. The TRV recommended by FSANZ for PFOS+ PFHxS has been adopted in this assessment, as it is consistent with the current guidance provided by Australian health and environmental regulators.

3 https://www.foodstandards.gov.au/publications/Documents/PFAS%20and%20Immunomodulatory%20Review%20and%20Update%202021.pdf

C-3-3 Bioavailability

The ASC NEPM (HEPA, 2020) defines bioavailability as the proportion of the intake of a substance, which is absorbed into the body. ‘Bioavailability’ can be separated into two distinct elements:

1. The ability of the substance to be liberated from a medium (e.g., plant or meat) within the gut or lung - often referred to as the bio-accessibility.
2. The ability of the substance to enter the bloodstream and be taken up by the body organs, once it has entered the lung or gut - this is often referred to as bioavailability (NEPC, 1999).

The toxicity data derived from experiments involving direct oral administration of PFAS to an animal or human intrinsically incorporates bioavailability as defined in Point 2 above. There has been limited research into bioaccessibility of PFAS in different media and therefore a conservative assumption of 100% bioaccessibility has been adopted in this assessment.

Appendix D

Human health exposure assessment supplementary information

D-1 Introduction

This appendix provides the technical details of the following aspects of the exposure assessment process:

– The data used to support the derivation of the background exposure assumption adopted in this HHRA.
– The methodologies used to estimate the relationship between PFAS concentrations in soil and groundwater and those in fruit and vegetables grown in Zones 1.
– The data used to calculate the direct exposure associated with soil and dust.

GHD developed a quantitative PFAS exposure model based on the methodology presented in the ASC NEPM Schedule B7, *Guidelines on Derivation of Health-Based Investigation Levels*. The model, including input data, reference, and calculations, is presented in Appendix E.

D-2 Background exposure to PFAS

D-2-1 Overview

According to the ASC NEPM, background exposure in the context of this HHRA refers to exposure from sources not associated with the MFS site. Background exposures to PFOS and PFHxS may be associated with releases attributable to identified sources of contamination and impacts that originate from other sources in the wider environment (such as PFAS present in food, water, and consumer products) and exposure in occupational settings. In Australia, typical sources of PFAS exposure include:

Specific identifiable sources

– **Point sources**: Near facilities where PFAS have been extensively used (e.g., fire stations, Defence bases or major airports) high PFAS levels may be found in the environment.
– **Occupational exposure:** Historically, PFAS was a major component of products such as firefighting foams and, therefore, a number of occupational groups (e.g. firefighters) experienced higher PFAS exposures than the general population. However, these kinds of exposures have decreased in recent years, as PFAS is phased out.

General sources

– **Household products**: PFAS are widely used in many common household products and specialty applications and, therefore, most people living in developed nations have some PFAS in their body that is related to the day-to-day use of products containing PFAS. Concentrations of PFOS in blood serum have been decreasing over time, following a reduction in production and use of PFOS containing products (ATSDR, 2021; EFSA, 2020)
– **Wider environmental sources:** Due to the widespread distribution, mobility and persistence of PFAS in the environment, these compounds are ubiquitous in the waterways of urban environment and are frequently found in potable and non-potable water supplies and in the human food chain. For most people, food is the primary source of exposure to PFAS (EFSA, 2020).

Consistent with the guidance provided in the ASC NEPM (NEPC, 1999), these other sources of exposure should be included in the HHRA. The TRV is linked to a tolerable total intake from all sources, which includes the site under investigation and background sources. If there is a likelihood of significant background exposure, a portion of the TRV should be assigned to the background before comparing exposures from site contamination to the TRV.

It is standard practice internationally to include a factor in the development of water quality standards, termed the Relative Source Contribution (RSC). The ADWG (NHMRC/NRMMC, 2011) default RSC of 0.1 assumes that a person gets only 10% of their daily PFAS exposure from drinking water, with the other 90% assumed to come from other sources (e.g., food, soil). This approach has been adopted by Australian regulators in the derivation of drinking water guidelines for PFAS (DoH, 2019) but is not appropriate for use in an HHRA that incorporates site-specific estimates of PFAS exposure via multiple pathways.

D-2-2 Background exposure studies

A variety of studies have been undertaken both within Australia and internationally on background PFAS exposures. Key studies are summarised herein.

Based on Australian biomonitoring data collected between 2010 and 2011, a report prepared by the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE, 2017) estimated a background intake rate of 0.89 ng/kg per day for PFOS. This value represents approximately 4.5% of the TRV presented in Section 4.1.

A study undertaken on the general population in Norway by Poothong *et al.* (2020), assessed the relative PFAS exposure associated with the ingestion of food and drinks, inhalation of air, ingestion of dust and dermal absorption. Although a high degree of variability was noted between study participants and PFAS exposures were generally very low, diet was the predominant exposure pathway. For PFOS 95% and 3% of the total PFOS intake came from dietary intakes and air inhalation, respectively, with dust ingestion and dermal absorption contributing less than 1% of the PFOS total intake.

EFSA (2020) undertook an evaluation on the risks to human health related to the presence of PFAS in food, which included measuring the PFAS concentration in over 90,000 food samples from 16 countries. This study indicated that the mean PFAS concentrations measured in food were of the most relevance to the assessment of PFAS exposures at a population level and the lower bound exposure estimates aligned most closely to the available data on PFAS concentrations in human blood. The mean lower bound dietary PFAS exposure estimates across surveys and age groups were generally similar and can be summarised as follows:

- PFOS: 0.23 – 2.6 ng/kg/day (1.2% to 13% of the TRV presented in Section 4.1)
- PFHxS: 0.04 - 0.36 ng/kg/day (0.2% to 1.8% of the TRV presented in Section 4.1)

The groups with the highest dietary exposures, when expressed in units of ng/kg/day were young children and the very elderly. Seafood was the primary source of PFAS exposure in most of the populations studied, with PFAS concentrations in freshwater fish being greater than those in marine fish. EFSA (2020) reported that dietary PFAS exposure was dominated by PFOS, PFHxS, PFOA and PFNA, with these compounds contributing to 46% of total dietary PFAS exposure.

A formal dietary exposure assessment has not been undertaken for PFAS in Australia, due to deficiencies in the available dataset (FSANZ, 2017), but the *24th Australian Total Diet Study (ATDS)* (FSANZ, 2016) included the analysis of PFAS in a range of foods sampled from a range of different retail outlets representing the buying habits of most of the community. The ATDS reported no detections for PFOA and only two detections for PFOS out of 50 foods tested and the concentrations of PFOS were at very low levels (1 part per billion). On this basis, FSANZ (2017) concluded that dietary exposure to PFAS from the general Australian food supply is likely to be low, with substantial PFAS exposure from food generally only likely to occur at PFAS contaminated sites.

Thompson *et al.* (2010) outline a pharmacokinetic modelling approach to characterize exposure of Australians to PFOS. Key parameters for this model include the elimination rate constants and the volume of distribution within the body and the serum concentrations of PFOS measured in the Australian population. The pharmacokinetic modelling estimated PFOS intake rates of between 1.1 – 2.3 ng/kg/day, for males and females aged 11 to 75 years (note that these values were presented in a corrigendum to the primary paper). The average intake rate of 1.5 ng/kg/day represents 7.4% of TRV presented in Section 4.1. The authors of the paper note that physiological differences between adults and children mean that the children (<11 years), who were not included in the study, could demonstrate higher chemical intake rates than adults when expressed per unit of body weight.

Nilsson (2022) assessed the PFAS blood serum concentration in current and former employees of an Australian corporation providing firefighting services, where aqueous film forming foam (AFFF) had been previously used (from the 1980s up until 2010). The authors found that the mean (arithmetic) serum concentrations of PFOS (27 ng/mL), PFHxS (14 ng/mL), and perfluoroheptane sulfonate (PFHpS, 1.7 ng/mL) among the participating firefighters were higher than the mean concentration of the general Australian population. The authors also noted that the reported serum concentrations were associated with the previous use of PFOS/PFHxS based AFFF.

D-2-3 Background exposure estimates

Overall, the available studies suggest that background exposures to PFAS in the general population are likely to be very low and that the background exposures that do occur are likely to occur primarily via the dietary pathway. The background exposure estimates for PFOS+PFHxS, made based on the studies outlined above range from range from 4.5% (CRC CARE, 2017; dietary exposure to PFOS in Australia) to 14.8% (EFSA, 2020; upper end of the range of mean dietary exposures estimates across survey and age groups in Europe).

A background exposure assumption of 10% has been adopted in this assessment, as a reasonable representation of the long-term background exposures that may be experienced by the Australian population.

D-3 Residential exposure scenario

D-3-1 Incidental ingestion of soil and dust

The incidental ingestion of soil and dust is an important exposure pathway for soil-borne contaminants. Young children are particularly prone to ingesting soil and dust as they have greater contact with soil during play and have not developed the avoidance strategies used by older individuals. Soil ingestion can occur both in the outdoor environment and indoors, where soil has been tracked in on shoes or clothing or blown indoors by the wind (enHealth, 2012a).

Rates of soil and dust ingestion have been studied overseas, using the tracer element methodology. These studies have been reviewed in detail by the US EPA (2008) and based on the recommendations provided in this document, enHealth (2012a) recommends the following default soil and dust ingestion rates:

– Children 0 to 1 years: 60 mg/day.
– Children 1 to 15 years: 100 mg/day, noting that for older children in this age range, this default assumption is likely to be conservative.
– Adults: 50 mg/day.

EnHealth (2012a) notes that for residences with a garden it can be assumed that up to approximately 50% of indoor dust is outdoor soil, with the remainder typically originating from sources including cooking and heating, residues from building components, hair, fibres, moulds and pollens.

The soil and dust ingestion rates recommended by the ASC NEPM and enHealth (2012a) have been used as the basis for the assumptions adopted in this assessment, with adjustments made to reflect site-specific circumstances, as summarised in Table D.8.1.

Table D.8.1 Incidental soil ingestion rate assumptions

Exposure scenario	Receptor	Soil and dust ingestion rate (mg/day)	Rationale
Future residents of Zone 1	Children under a low-density residential setting	100	The NSW OEH (2019) soil and dust ingestion rate for residential land uses.
	Children under a high density residential setting	12.5	The NSW OEH (2019) soil and dust ingestion rate for residential land uses.
	Children under a medium density residential setting	56.25	Mid-point between HIL A and HIL B

D-3-2 Inhalation of dust

The HHRA has considered exposure to PFAS via the inhalation of dust from contaminated soil, both indoors and outdoors, in line with the ASC NEPM approach. Calculations and input data are shown in Appendix E. Exposure via this pathway depends on three key factors, as discussed below.

1. **Outdoor dust concentrations** – For residential settings, soil-derived dust concentrations in outdoor air were calculated using an outdoor particulate emission factor (PEF_o) based on models presented in EA (2009) and US EPA (2002). These models relate the concentration of respirable dust particles (diameter <10 µm) in the air with wind speed (site-specific), surface cover (assumed to be 75% to 90% hard surface under residential settings, in line with the ASC NEPM), and the area of the investigated area (i.e., Zones 2a and 2b) occupied by exposed soil.

   The outdoor dust concentration was assumed to consist of 100% site-derived soil, a conservative approach.
2. **Indoor dust concentrations** – Soil-derived dust concentrations in indoor air were calculated using the approach proposed by EA (2009) that assumes indoor dust concentrations equilibrate with outdoor dust levels through natural building ventilation. Indoor air is considered to be enriched with dust compared to the outdoor environment due to the movement of dust indoors on, for instance, clothing and footwear. The indoor dust concentration (i.e., dust loading factor – DL) is assumed to be equal to the 95th percentile from Australian data (enHealth, 2012a), which is 39 µg/m^3. Approximately 50% of indoor dust was assumed to derived from the soil in Zones 2a and 2b, while the rest from other sources (largely resuspension of floor dust), in line with the ASC NEPM. Based on this assumption an indoor particulate emission factor (PEF_i) was calculated as shown in Appendix E.
3. **Dust lung retention factor** – In accordance with the ASC NEPM, a dust lung retention factor (LF) of 37.5% was used in this HHRA to estimate the percentage of respirable dust that is small enough to be retained in lungs and is associated with health effects.

D-3-3 Bioaccumulation in fruit and vegetables

This HHRA considered the bioaccumulation of PFAS in homegrown fruit and vegetables grown in Zones 2a and 2b via two migration pathways as follows:

– The uptake of PFAS from shallow groundwater in Zone 2a.
– The uptake of PFAS from soil in Zones 2a and 2b.

The critical factor determining the influence of PFAS concentrations in soil and shallow groundwater uptake on the PFAS concentrations in domestically produced fruit and vegetables, is the efficiency with which PFAS is transferred from the water and soil to plants.

The NSW Office of Environment and Heritage (OEH, 2019) details the methodologies used to derive the HILs adopted in the PFAS NEMP for PFAS in soil, with the HIL A values incorporating consideration of the uptake of PFOS and PFHxS impacts in soil by plants. The transfer factors adopted in this document for PFOS+PFHxS are as follows:

– Green vegetables: 0.2
– Root vegetables: 0.13
– Tuber vegetables: 0.05
– Tree fruit: 0.005

OEH (2019) also notes that while the extent to which PFHxS are transferred from soil to plant tissues is less studied than for PFOS, the available studies suggest that uptake from soil of shorter chain PFAAs (e.g. PFHxS) is greater than longer chain PFAAs (e.g. PFOS). Based on the geometric mean of the ratio of the transfer factors reported in the scientific literature for PFHxS relative to the those reported for PFOS, OEH (2019) multiplies the PFOS transfer factors by 6.9 to derive transfer factors relevant to PFHxS.

The draft PFAS NEMP 3.0 (HEPA, 2022) includes a review of the PFAS NEMP plant transfer factors. The updated transfer factors are generally consistent with the original values, with the exception of the tree fruit with a higher value (0.015) recommended.

The OEH (2019) document provides the most detailed review of PFOS, and PFHxS plant transfer factors published in an Australian guideline document. The OEH (2019) PFOS transfer factors for fruit and vegetables from soil have been adopted in this assessment with the recommended 6.9 scaling factor applied. The marginally higher transfer factor identified by HEPA (2022) has also been adopted for tree fruit, as a conservative approach.

Blaine *et al.* (2014) completed a study that assessed the relative effect of PFAS impacted biosolids and PFAS-impacted reclaimed water on the accumulation of PFAS by lettuce and strawberry plants in a soil media. The key results of this study were as follows:

- Approximately linear relationships between the PFOS and PFHxS concentrations in the reclaimed water and the concentrations in the lettuce tissue, with average wet weight transfer factors of 0.3 and 0.6. PFOS and PFHxS were not detected in strawberry plants irrigated with reclaimed water, with only short chain PFAS detected
- Lower transfer factors for PFOS and PFHxS were demonstrated in the irrigated lettuce plants grown in soils with higher concentrations of organic carbon, suggesting that the bioavailability of PFOS and PFHxS in irrigation water may have been reduced via complexing with organic carbon in soil.
- The transfer factors demonstrated by lettuce plants grown in PFAS-impacted biosolids-amended soils were lower than those demonstrated by lettuce plants irrigated with PFAS impacted reclaimed water. This difference was hypothesized to be related to the occurrence of immediate plant uptake of aqueous supplied PFAS, prior to adsorption in the soil
- The difference in the transfer factor associated with PFAS delivered via irrigation and biosolids amendment was greater for shorter chain compounds than for longer chain compounds, such as PFOS (carbon chain length 8) and PFHxS (carbon chain length 6).

The OEH (2019) review is specific to soil borne PFAS and the data presented by Blaine *et al.* (2014) suggests that PFOS and PFHxS in water may be more bioavailable. Limited studies specific to the assessment of PFAS uptake from groundwater or irrigation water have been identified and, therefore, the OEH (2019) transfer factors have been used as the basis for the exposure assessment in this HHRA. These values have, however, been adjusted upwards by a factor of 5, to reflect to possibility that PFOS and PFHxS contained in shallow groundwater may be more bioavailable than soil borne PFOS and PFHxS.

As a conservative approach is has been assumed that 50% of the water required by homegrown plants is obtained from shallow/perched groundwater within Zone 2a.

An impacted shallow aquifer is not known to be present in Zone 2b (upgradient of the site). Hence, this exposure pathway was not included for future residents of Zone 2b.

The plant transfer modelling algorithms and the modelling inputs and outputs is provided in Appendix E.

Appendix E

Human Health Risk Assessment modelling inputs and outputs

Area	Zone 1 (Produce consumption - 1%)
Exposure Media	Soil
Receptor Group	Children (2-6 years)
Chemicals of Potential Concern	PFOS+PFHxS

Parameter	Unit	Value	Details	Source
Soil quality inputs				
Concentration in soil (C_s)	**mg/kg**	**3.829**	Maximum concentration in Zone 1	Site-specific
Percentage PFHxS	**%**	**1%**	PFHxS was below the LoR in the majority of Zone 2a soil samples	Site-specific
Risk calculations				
HQ_{Garden}	-	**2.0E+00**	$HQ_{Pathway} = \frac{Intake_{Pathway}}{TRV\ x\ (100\% - Background)}$	Calculated - based on ASC NEPM algorithms
Intake calculations				
$Intake_{Garden}$	mg/kg/day	**3.6E-05**	$Intake_{Garden} = \frac{C_{Garden}\ x\ IR_{Garden}\ x\ F_{HG\_garden}\ x\ BIO\ x\ EF\ x\ ED}{BW\ x\ AT}$	Calculated - based on ASC NEPM algorithms
General toxicity and exposure inputs				
TRV	mg/kg/day	0.00002	Based on body weight effects in animal reproductive toxicity studies	FSANZ (2017)
$TRV_{Inhalation}$	mg/m^3	0.00007	Calculated based on the TRV and an adult inhaltion rate of $20m^3$/day	ASC NEPM
Background	%	10%	Conservative assumption, calculated on the basis dietary concentrations in Europe and serum concentrations in the Australian population	EFSA (2020), FSANZ (2017), Thompson (2010)
Body weight (BW)	kg	19	Mean body weight of children aged 2-6 years.	FSANZ (2017)
Averaging time (AT)	days	2190	Exposure duration x 365 days/yr. Multipled by 24 for inhalation exposures	ASC NEPM
Exposure frequency (EF)	days/yr	365	Daily - permanent resident	NEPC (1999)
Exposure duration (ED)	years	6	Childhood	ASC NEPM
Oral bioavailability (BIO)	-	1	Assumes that ingested PFAS is largely bioaccessible	OEH (2019)
Fruit and vegetable consumption exposure inputs				
Fraction produced in impacted soil ($F_{IGarden}$)	%	100%	Site specific assumption - assumes that the produce garden has the maximum PFOS+PFHxS concentration reported in Zone 2a	Assumption
Fraction of homegrown produce (F_{HG_Garden})	%	1%	Standard assumption for low density residential settings	ASC NEPM
Concentration in green vegetables ($C_{GreenVeg}$)	mg/kg	8.0E-01	$C_{Produce} = TF_{Produce}\ x\ C_s\ x\ F_{IGarden}$	OEH (2019)
Concentration in root vegetables ($C_{RootVeg}$)	mg/kg	5.2E-01		OEH (2019)
Concentration in tuber vegetables ($C_{TuberVeg}$)	mg/kg	2.0E-01		OEH (2019)
Concentration in fruit (C_{Fruit})	mg/kg	6.0E-02		OEH (2019)
Green vegetable consumption rate ($C_{GreenVeg}$)	kg/day	5.5E-02	Mean total fruit and vegetable consumption rates reported for the Australian population (2-6 years)	OEH (2019)
Root vegetable consumption rate ($C_{RootVeg}$)	kg/day	1.7E-02		
Tuber vegetable consumption rate ($C_{TuberVeg}$)	kg/day	2.8E-02		
Fruit consumption rate ($C_{FruitVeg}$)	kg/day	1.8E-01		
Transfer to green vegetables ($TF_{GreenVeg}$)	-	0.21	The maximum wet weight transfer factor for each produce category in soil. The PFOS+PFHxS transfer factor reflects the proportion of PFHxS in water and a multiplier of 6.9	OEH (2019)
Transfer to root vegetables ($TF_{RootVeg}$)	-	0.05		OEH (2019)
Transfer to tuber vegetables ($TF_{TuberVeg}$)	-	0.14		OEH (2019)
Transfer to fruits (TF_{Fruit})	-	0.02		PFAS NEMP 3.0

Area	Zone 1 (Produce consumption - 10%)
Exposure Media	Soil
Receptor Group	Children (2-6 years)
Chemicals of Potential Concern	PFOS+PFHxS

Parameter	Unit	Value	Details	Source
Soil quality inputs				
Concentration in soil (C_s)	**mg/kg**	**3.829**	Maximum concentration in Zone 1	Site-specific
Percentage PFHxS	**%**	**1%**	PFHxS was below the LoR in the majority of Zone 2a soil samples	Site-specific
Risk calculations				
HQ_{Garden}	-	**2.0E+01**	$HQ_{Pathway} = \frac{Intake_{Pathway}}{TRV\ x\ (100\% - Background)}$	Calculated - based on ASC NEPM algorithms
Intake calculations				
$Intake_{Garden}$	mg/kg/day	**3.6E-04**	$Intake_{Garden} = \frac{C_{Garden}\ x\ IR_{Garden}\ x\ F_{HG\_garden}\ x\ BIO\ x\ EF\ x\ ED}{BW\ x\ AT}$	Calculated - based on ASC NEPM algorithms
General toxicity and exposure inputs				
TRV	mg/kg/day	0.00002	Based on body weight effects in animal reproductive toxicity studies	FSANZ (2017)
$TRV_{Inhalation}$	mg/m^3	0.00007	Calculated based on the TRV and an adult inhaltion rate of $20m^3$/day	ASC NEPM
Background	%	10%	Conservative assumption, calculated on the basis dietary concentrations in Europe and serum concentrations in the Australian population	EFSA (2020), FSANZ (2017), Thompson (2010)
Body weight (BW)	kg	19	Mean body weight of children aged 2-6 years.	FSANZ (2017)
Averaging time (AT)	days	2190	Exposure duration x 365 days/yr. Multipled by 24 for inhalation exposures	ASC NEPM
Exposure frequency (EF)	days/yr	365	Daily - permanent resident	NEPC (1999)
Exposure duration (ED)	years	6	Childhood	ASC NEPM
Oral bioavailability (BIO)	-	1	Assumes that ingested PFAS is largely bioaccessible	OEH (2019)
Fruit and vegetable consumption exposure inputs				
Fraction produced in impacted soil ($F_{IGarden}$)	%	100%	Site specific assumption - assumes that the produce garden has the maximum PFOS+PFHxS concentration reported in Zone 2a	Assumption
Fraction of homegrown produce (F_{HG_Garden})	%	10%	Standard assumption for low density residential settings	ASC NEPM
Concentration in green vegetables ($C_{GreenVeg}$)	mg/kg	8.0E-01	$C_{Produce} = TF_{Produce}\ x\ C_s\ x\ F_{IGarden}$	OEH (2019)
Concentration in root vegetables ($C_{RootVeg}$)	mg/kg	5.2E-01		OEH (2019)
Concentration in tuber vegetables ($C_{TuberVeg}$)	mg/kg	2.0E-01		OEH (2019)
Concentration in fruit (C_{Fruit})	mg/kg	6.0E-02		OEH (2019)
Green vegetable consumption rate ($C_{GreenVeg}$)	kg/day	5.5E-02	Mean total fruit and vegetable consumption rates reported for the Australian population (2-6 years)	OEH (2019)
Root vegetable consumption rate ($C_{RootVeg}$)	kg/day	1.7E-02		
Tuber vegetable consumption rate ($C_{TuberVeg}$)	kg/day	2.8E-02		
Fruit consumption rate ($C_{FruitVeg}$)	kg/day	1.8E-01		
Transfer to green vegetables ($TF_{GreenVeg}$)	-	0.21	The maximum wet weight transfer factor for each produce category in soil. The PFOS+PFHxS transfer factor reflects the proportion of PFHxS in water and a multiplier of 6.9	OEH (2019)
Transfer to root vegetables ($TF_{RootVeg}$)	-	0.05		OEH (2019)
Transfer to tuber vegetables ($TF_{TuberVeg}$)	-	0.14		OEH (2019)
Transfer to fruits (TF_{Fruit})	-	0.02		PFAS NEMP 3.0

Area	Zone 1 - Childcare (High Density)
Exposure Media	Soil
Receptor Group	Children (2-6 years)
Chemicals of Potential Concern	PFOS+PFHxS

Parameter	Unit	Value	Details	Source
Soil quality inputs				
Concentration in soil (C_s)	**mg/kg**	**3.829**	Maximum concentration in Zone 1	Site-specific
Percentage PFHxS	**%**	**1%**	PFHxS was below the LoR in the majority of Zone 2a soil samples	Site-specific
Risk calculations				
HI_{Total}	-	**1.8E-01**	$HI = \sum HQ_{All\ pathwways}$	Calculated - based on ASC NEPM algorithms
$HQ_{Ingestion}$	-	**1.8E-01**	$HQ_{Pathway} = \frac{Intake_{Pathway}}{TRV\ x\ (100\% - Background)}$	
$HQ_{Inhalation}$	-	**7.1E-05**		
Intake calculations				
$Intake_{Total}$	mg/kg/day	**3.3E-06**	$Intake_{Total} = \sum Intake_{All\ pathways}$	Calculated - based on ASC NEPM algorithms
$Intake_{Ingestion}$	mg/kg/day	**3.3E-06**	$Intake_{Ingestion} = \frac{C_s\ x\ IR_s x\ EF\ x\ ED}{BW\ x\ AT}$	
$Intake_{Inhalation}$	mg/m^3	**4.5E-09**	$Intake_{Inhalation} = \frac{C_s\ x\ \left(\frac{1}{PEF_o}\ x\ ET_o + \frac{1}{PEF_i} x\ TF\ x\ ET_i\right) x\ LFx\ EF\ x\ ED}{AT}$	
Pathway contribution calculations				
$Contribution_{Ingestion}$	%	100%	$Contribution_{Pathway} = \frac{Intake_{Pathway}}{Intake_{\ Total}}\ x\ 100\%$	Calculation
$Contribution_{Inhalation}$	%	0.1%		
General toxicity and exposure inputs				
TRV	mg/kg/day	0.00002	Based on body weight effects in animal reproductive toxicity studies	FSANZ (2017)
$TRV_{Inhalation}$	mg/m^3	0.00007	Calculated based on the TRV and an adult inhaltion rate of 20m^3/day	ASC NEPM
Background	%	10%	Conservative assumption, calculated on the basis dietary concentrations in Europe and serum concentrations in the Australian population	EFSA (2020), FSANZ (2017), Thompson (2010)
Body weight (BW)	kg	19	Mean body weight of children aged 2-6 years.	FSANZ (2017)
Averaging time (AT)	days	2190	Exposure duration x 365 days/yr. Multipled by 24 for inhalation exposures	ASC NEPM
Exposure frequency (EF)	days/yr	240	Five days per week	NEPC (1999)
Exposure duration (ED)	years	6	Childhood	ASC NEPM
Oral bioavailability (BIO)	-	1	Assumes that ingested PFAS is largely bioaccessible	OEH (2019)
Soil ingestion exposure inputs				
Ingestion rate (IR_s)	mg/day	25	Average daily incidental soil ingestion rate (HIL A default)	ASC NEPM
Inhalation exposure inputs				
Time Spent Outdoors (ET_o)	hr/day	4	8 hours per day - 50% indoor/outdoor	ASC NEPM
Time Spent Indoors (ET_i)	hr/day	4	8 hours per day - 50% indoor/outdoor	ASC NEPM
Fraction of indoor dust comprised of soil (TF)	-	0.5	Default value	ASC NEPM
Particle emission factor (PEF_o)	m^3/kg	1.1E+08	Calculated	ASC NEPM
Indoor dust factor (PEF_i)	m^3/kg	2.6E+07	Calculated (75% building and hardstand)	ASC NEPM
Lung retention factor (LF)	-	0.375	Default value	ASC NEPM

Area	Zone 1 (Residential - High Density)
Exposure Media	Soil
Receptor Group	Children (2-6 years)
Chemicals of Potential Concern	PFOS+PFHxS

Parameter	Unit	Value	Details	Source
Soil quality inputs				
Concentration in soil (C_s)	**mg/kg**	**3.829**	Maximum concentration in Zone 1	Site-specific
Percentage PFHxS	**%**	**1%**	PFHxS was below the LoR in the majority of Zone 2a soil samples	Site-specific
Risk calculations				
HI_{Total}	-	**2.8E-01**	$HI = \sum HQ_{All\ pathwways}$	Calculated - based on ASC NEPM algorithms
$HQ_{Ingestion}$	-	**2.8E-01**	$HQ_{Pathway} = \frac{Intake_{Pathway}}{TRV\ x\ (100\% - Background)}$	
$HQ_{Inhalation}$	-	**4.0E-04**		
Intake calculations				
$Intake_{Total}$	mg/kg/day	**5.0E-06**	$Intake_{Total} = \sum Intake_{All\ pathways}$	Calculated - based on ASC NEPM algorithms
$Intake_{Ingestion}$	mg/kg/day	**5.0E-06**	$Intake_{Ingestion} = \frac{C_s\ x\ IR_s x\ EF\ x\ ED}{BW\ x\ AT}$	
$Intake_{Inhalation}$	mg/m^3	**2.5E-08**	$Intake_{Inhalation} = \frac{C_s\ x\ \left(\frac{1}{PEF_o}\ x\ ET_o + \frac{1}{PEF_i} x\ TF\ x\ ET_i\right) x\ LFx\ EF\ x\ ED}{AT}$	
Pathway contribution calculations				
$Contribution_{Ingestion}$	%	100%	$Contribution_{Pathway} = \frac{Intake_{Pathway}}{Intake_{\ Total}}\ x\ 100\%$	Calculation
$Contribution_{Inhalation}$	%	0.5%		
General toxicity and exposure inputs				
TRV	mg/kg/day	0.00002	Based on body weight effects in animal reproductive toxicity studies	FSANZ (2017)
$TRV_{Inhalation}$	mg/m^3	0.00007	Calculated based on the TRV and an adult inhaltion rate of 20m^3/day	ASC NEPM
Background	%	10%	Conservative assumption, calculated on the basis dietary concentrations in Europe and serum concentrations in the Australian population	EFSA (2020), FSANZ (2017), Thompson (2010)
Body weight (BW)	kg	19	Mean body weight of children aged 2-6 years.	FSANZ (2017)
Averaging time (AT)	days	2190	Exposure duration x 365 days/yr. Multipled by 24 for inhalation exposures	ASC NEPM
Exposure frequency (EF)	days/yr	365	Daily - permanent resident	NEPC (1999)
Exposure duration (ED)	years	6	Childhood	ASC NEPM
Oral bioavailability (BIO)	-	1	Assumes that ingested PFAS is largely bioaccessible	OEH (2019)
Soil ingestion exposure inputs				
Ingestion rate (IR_s)	mg/day	25	Average daily incidental soil ingestion rate (HIL A default)	ASC NEPM
Inhalation exposure inputs				
Time Spent Outdoors (ET_o)	hr/day	4	Default value (HIL A)	ASC NEPM
Time Spent Indoors (ET_i)	hr/day	20	Default value (HIL A)	ASC NEPM
Fraction of indoor dust comprised of soil (TF)	-	0.5	Default value	ASC NEPM
Particle emission factor (PEF_o)	m^3/kg	1.1E+08	Calculated	ASC NEPM
Indoor dust factor (PEF_i)	m^3/kg	2.6E+07	Calculated (75% building and hardstand)	ASC NEPM
Lung retention factor (LF)	-	0.375	Default value	ASC NEPM

Soil-to-Air Particulate Emission Factor Calculations

Exposure Parameter	Abbreviation	Units	Parameter	References
Area of site	A_{site}	Acres	0.50	Assumed as default (minimum)
Constant	A	-	11.68	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	B	-	23.49	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	C	-	288.00	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Dispersion factor	Q/C	$g/m^2/s$ per kg/m^3	89.03	Calculated according to US EPA (2002) methodology $Q / C = A \times \exp\left[\frac{(\ln A_{site} - B)^2}{C}\right]$
Fraction of vegetative cover	V	Unitless	0.9	ASC NEPM default assumption
Mean annual windspeed	U_m	m/s	6.1	Site specific - Based on the mean 3 pm wind speed recorded at Parafield Airport (BoM Station no. 023013) between 1939 and 2010
Equivalent threshold value	U_t	m/s	7.2	ASC NEPM, Schedule B8; default as per UK EA (2009)
Constant	x	Unitless	1.0	Constant from Cowherd *et al.* (1985) $x = 0.886 \frac{U_t}{U_m}$
Windspeed distribution function	F_x	Unitless	1.308	Calculated according to ASC NEPM $F_x = 0.18 \times (8x^3 + 12x)\exp(-x^2)$
Indoor dust loading factor	DL	mg/m^3	0.039	ASC NEPM, Schedule B7; 95th percentile from Australian data (enHealth 2012)
Particulate emission factor outdoor	PEF_o	mg/m^3	1.1E+08	Relates the concentration of respirable dust particles (<10 µm) in the air with wind speed, vegetative cover and the area of the site occupied by exposed soil. Assumes 100% site-derived soil $PEF_o\,(m^3/kg) = \frac{Q/C \times 3600}{0.036 \times (1-V) \times (\frac{U_m}{U_t})^3 \times F_x}$
Particulate emission factor indoor	PEF_i	mg/m^3	2.6E+07	Indoor dust concentrations are assumed to equilibrate with outdoor dust concentrations through building ventilation. Indoor air is also enriched with dust compared to the outdoor environment, due to the movement of dust indoors on clothing, footwear, etc., as described by the indoor dust loading factor (DL) $PEF_i\,(m^3/kg) = \frac{1}{DL \times 10^{-6}}$

Area	Zone 1 (Childcare - Low Density)
Exposure Media	Soil
Receptor Group	Children (2-6 years)
Chemicals of Potential Concern	PFOS+PFHxS

Parameter	Unit	Value	Details	Source
Soil quality inputs				
Concentration in soil (C_s)	**mg/kg**	**3.829**	Maximum concentration in Zone 1	Site-specific
Percentage PFHxS	**%**	**1%**	PFHxS was below the LoR in the majority of Zone 2a soil samples	Site-specific
Risk calculations				
HI_{Total}	-	**7.4E-01**	$HI = \sum HQ_{All\ pathwways}$	Calculated - based on ASC NEPM algorithms
$HQ_{Ingestion}$	-	**7.4E-01**	$HQ_{Pathway} = \frac{Intake_{Pathway}}{TRV\ x\ (100\% - Background)}$	
$HQ_{Inhalation}$	-	**1.0E-04**		
Intake calculations				
$Intake_{Total}$	mg/kg/day	**1.3E-05**	$Intake_{Total} = \sum Intake_{All\ pathways}$	Calculated - based on ASC NEPM algorithms
$Intake_{Ingestion}$	mg/kg/day	**1.3E-05**	$Intake_{Ingestion} = \frac{C_s\ x\ IR_s x\ EF\ x\ ED}{BW\ x\ AT}$	
$Intake_{Inhalation}$	mg/m^3	**6.6E-09**	$Intake_{Inhalation} = \frac{C_s\ x\ \left(\frac{1}{PEF_o}\ x\ ET_o + \frac{1}{PEF_i} x\ TF\ x\ ET_i\right) x\ LF x\ EF\ x\ ED}{AT}$	
Pathway contribution calculations				
$Contribution_{Ingestion}$	%	100%	$Contribution_{Pathway} = \frac{Intake_{Pathway}}{Intake_{Total}}\ x\ 100\%$	Calculation
$Contribution_{Inhalation}$	%	0.0%		
General toxicity and exposure inputs				
TRV	mg/kg/day	0.00002	Based on body weight effects in animal reproductive toxicity studies	FSANZ (2017)
$TRV_{Inhalation}$	mg/m^3	0.00007	Calculated based on the TRV and an adult inhaltion rate of 20m^3/day	ASC NEPM
Background	%	10%	Conservative assumption, calculated on the basis dietary concentrations in Europe and serum concentrations in the Australian population	EFSA (2020), FSANZ (2017), Thompson (2010)
Body weight (BW)	kg	19	Mean body weight of children aged 2-6 years.	FSANZ (2017)
Averaging time (AT)	days	2190	Exposure duration x 365 days/yr. Multipled by 24 for inhalation exposures	ASC NEPM
Exposure frequency (EF)	days/yr	240	Five days per week	NEPC (1999)
Exposure duration (ED)	years	6	Childhood	ASC NEPM
Oral bioavailability (BIO)	-	1	Assumes that ingested PFAS is largely bioaccessible	OEH (2019)
Soil ingestion exposure inputs				
Ingestion rate (IR_s)	mg/day	100	Average daily incidental soil ingestion rate (HIL A default)	ASC NEPM
Inhalation exposure inputs				
Time Spent Outdoors (ET_o)	hr/day	4	8 hours per day - 50% indoors/outdoors	ASC NEPM
Time Spent Indoors (ET_i)	hr/day	4	8 hours per day - 50% indoors/outdoors	ASC NEPM
Fraction of indoor dust comprised of soil (TF)	-	0.5	Default value	ASC NEPM
Particle emission factor (PEF_o)	m^3/kg	4.5E+07	Calculated	ASC NEPM
Indoor dust factor (PEF_i)	m^3/kg	2.6E+07	Calculated (75% building and hardstand)	ASC NEPM
Lung retention factor (LF)	-	0.375	Default value	ASC NEPM

Area	Zone 1 (Residential - Low Density)
Exposure Media	Soil
Receptor Group	Children (2-6 years)
Chemicals of Potential Concern	PFOS+PFHxS

Parameter	Unit	Value	Details	Source
Soil quality inputs				
Concentration in soil (C_s)	**mg/kg**	**3.829**	Maximum concentration in Zone 1	Site-specific
Percentage PFHxS	**%**	**1%**	PFHxS was below the LoR in the majority of Zone 2a soil samples	Site-specific
Risk calculations				
HI_{Total}	-	**1.1E+00**	$HI = \sum HQ_{All\ pathwways}$	Calculated - based on ASC NEPM algorithms
$HQ_{Ingestion}$	-	**1.1E+00**	$HQ_{Pathway} = \frac{Intake_{Pathway}}{TRV\ x\ (100\% - Background)}$	
$HQ_{Inhalation}$	-	**4.6E-04**		
Intake calculations				
$Intake_{Total}$	mg/kg/day	**2.0E-05**	$Intake_{Total} = \sum Intake_{All\ pathways}$	Calculated - based on ASC NEPM algorithms
$Intake_{Ingestion}$	mg/kg/day	**2.0E-05**	$Intake_{Ingestion} = \frac{C_s\ x\ IR_s x\ EF\ x\ ED}{BW\ x\ AT}$	
$Intake_{Inhalation}$	mg/m^3	**2.9E-08**	$Intake_{Inhalation} = \frac{C_s\ x\ \left(\frac{1}{PEF_o}\ x\ ET_o + \frac{1}{PEF_i} x\ TF\ x\ ET_i\right) x\ LF x\ EF\ x\ ED}{AT}$	
Pathway contribution calculations				
$Contribution_{Ingestion}$	%	100%	$Contribution_{Pathway} = \frac{Intake_{Pathway}}{Intake_{Total}}\ x\ 100\%$	Calculation
$Contribution_{Inhalation}$	%	0.1%		
General toxicity and exposure inputs				
TRV	mg/kg/day	0.00002	Based on body weight effects in animal reproductive toxicity studies	FSANZ (2017)
$TRV_{Inhalation}$	mg/m^3	0.00007	Calculated based on the TRV and an adult inhaltion rate of 20m^3/day	ASC NEPM
Background	%	10%	Conservative assumption, calculated on the basis dietary concentrations in Europe and serum concentrations in the Australian population	EFSA (2020), FSANZ (2017), Thompson (2010)
Body weight (BW)	kg	19	Mean body weight of children aged 2-6 years.	FSANZ (2017)
Averaging time (AT)	days	2190	Exposure duration x 365 days/yr. Multipled by 24 for inhalation exposures	ASC NEPM
Exposure frequency (EF)	days/yr	365	Daily - permanent resident	NEPC (1999)
Exposure duration (ED)	years	6	Childhood	ASC NEPM
Oral bioavailability (BIO)	-	1	Assumes that ingested PFAS is largely bioaccessible	OEH (2019)
Soil ingestion exposure inputs				
Ingestion rate (IR_s)	mg/day	100	Average daily incidental soil ingestion rate (HIL A default)	ASC NEPM
Inhalation exposure inputs				
Time Spent Outdoors (ET_o)	hr/day	4	Default value (HIL A)	ASC NEPM
Time Spent Indoors (ET_i)	hr/day	20	Default value (HIL A)	ASC NEPM
Fraction of indoor dust comprised of soil (TF)	-	0.5	Default value	ASC NEPM
Particle emission factor (PEF_o)	m^3/kg	4.5E+07	Calculated	ASC NEPM
Indoor dust factor (PEF_i)	m^3/kg	2.6E+07	Calculated (75% building and hardstand)	ASC NEPM
Lung retention factor (LF)	-	0.375	Default value	ASC NEPM

Soil-to-Air Particulate Emission Factor Calculations

Exposure Parameter	Abbreviation	Units	Parameter	References
Area of site	A_{site}	Acres	0.50	Assumed as default (minimum)
Constant	A	-	11.68	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	B	-	23.49	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	C	-	288.00	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Dispersion factor	Q/C	$g/m^2/s$ per kg/m^3	89.03	Calculated according to US EPA (2002) methodology $Q/C = A \times \exp\left[\frac{(\ln A_{site} - B)^2}{C}\right]$
Fraction of vegetative cover	V	Unitless	0.75	ASC NEPM default assumption
Mean annual windspeed	U_m	m/s	6.1	Site specific - Based on the mean 3 pm wind speed recorded at Parafield Airport (BoM Station no. 023013) between 1939 and 2010
Equivalent threshold value	U_t	m/s	7.2	ASC NEPM, Schedule B8; default as per UK EA (2009)
Constant	x	Unitless	1.0	Constant from Cowherd *et al.* (1985) $x = 0.886\frac{U_t}{U_m}$
Windspeed distribution function	F_x	Unitless	1.308	Calculated according to ASC NEPM $F_x = 0.18 \times (8x^3 + 12x)\exp(-x^2)$
Indoor dust loading factor	DL	mg/m^3	0.039	ASC NEPM, Schedule B7; 95th percentile from Australian data (enHealth 2012)
Particulate emission factor outdoor	PEF_o	mg/m^3	4.5E+07	Relates the concentration of respirable dust particles (<10 µm) in the air with wind speed, vegetative cover and the area of the site occupied by exposed soil. Assumes 100% site-derived soil $PEF_o\,(m^3/kg) = \frac{Q/C \times 3600}{0.036 \times (1-V) \times (\frac{U_m}{U_t})^3 \times F_x}$
Particulate emission factor indoor	PEF_i	mg/m^3	2.6E+07	Indoor dust concentrations are assumed to equilibrate with outdoor dust concentrations through building ventilation. Indoor air is also enriched with dust compared to the outdoor environment, due to the movement of dust indoors on clothing, footwear, etc., as described by the indoor dust loading factor (DL) $PEF_i\,(m^3/kg) = \frac{1}{DL \times 10^{-6}}$

Area	Zone 1 (Childcare - Medium Density)
Exposure Media	Soil
Receptor Group	Children (2-6 years)
Chemicals of Potential Concern	PFOS+PFHxS

Parameter	Unit	Value	Details	Source
Soil quality inputs				
Concentration in soil (C_s)	**mg/kg**	**3.829**	Maximum concentration in Zone 1	Site-specific
Percentage PFHxS	**%**	**1%**	PFHxS was below the LoR in the majority of Zone 2a soil samples	Site-specific
Risk calculations				
HI_{Total}	-	**4.6E-01**	$HI = \sum HQ_{All\ pathwways}$	Calculated - based on ASC NEPM algorithms
$HQ_{Ingestion}$	-	**4.6E-01**	$HQ_{Pathway} = \frac{Intake_{Pathway}}{TRV\ x\ (100\% - Background)}$	
$HQ_{Inhalation}$	-	**8.8E-05**		
Intake calculations				
$Intake_{Total}$	mg/kg/day	**8.3E-06**	$Intake_{Total} = \sum Intake_{All\ pathways}$	Calculated - based on ASC NEPM algorithms
$Intake_{Ingestion}$	mg/kg/day	**8.3E-06**	$Intake_{Ingestion} = \frac{C_s\ x\ IR_s x\ EF\ x\ ED}{BW\ x\ AT}$	
$Intake_{Inhalation}$	mg/m^3	**5.5E-09**	$Intake_{Inhalation} = \frac{C_s\ x\ \left(\frac{1}{PEF_o}\ x\ ET_o + \frac{1}{PEF_i} x\ TF\ x\ ET_i\right) x\ LFx\ EF\ x\ ED}{AT}$	
Pathway contribution calculations				
$Contribution_{Ingestion}$	%	100%	$Contribution_{Pathway} = \frac{Intake_{Pathway}}{Intake_{Total}}\ x\ 100\%$	Calculation
$Contribution_{Inhalation}$	%	0.1%		
General toxicity and exposure inputs				
TRV	mg/kg/day	0.00002	Based on body weight effects in animal reproductive toxicity studies	FSANZ (2017)
$TRV_{Inhalation}$	mg/m^3	0.00007	Calculated based on the TRV and an adult inhaltion rate of $20m^3$/day	ASC NEPM
Background	%	10%	Conservative assumption, calculated on the basis dietary concentrations in Europe and serum concentrations in the Australian population	EFSA (2020), FSANZ (2017), Thompson (2010)
Body weight (BW)	kg	19	Mean body weight of children aged 2-6 years.	FSANZ (2017)
Averaging time (AT)	days	2190	Exposure duration x 365 days/yr. Multipled by 24 for inhalation exposures	ASC NEPM
Exposure frequency (EF)	days/yr	240	Five days per week	NEPC (1999)
Exposure duration (ED)	years	6	Childhood	ASC NEPM
Oral bioavailability (BIO)	-	1	Assumes that ingested PFAS is largely bioaccessible	OEH (2019)
Soil ingestion exposure inputs				
Ingestion rate (IR_s)	mg/day	63	Average daily incidental soil ingestion rate (Average of HIL A/HIL B defaults)	ASC NEPM
Inhalation exposure inputs				
Time Spent Outdoors (ET_o)	hr/day	4	8 hours per day - 50% indoors/outdoors	ASC NEPM
Time Spent Indoors (ET_i)	hr/day	4	8 hours per day - 50% indoors/outdoors	ASC NEPM
Fraction of indoor dust comprised of soil (TF)	-	0.5	Default value	ASC NEPM
Particle emission factor (PEF_o)	m^3/kg	6.4E+07	Calculated	ASC NEPM
Indoor dust factor (PEF_i)	m^3/kg	2.6E+07	Calculated (82.5% building and hardstand)	ASC NEPM
Lung retention factor (LF)	-	0.375	Default value	ASC NEPM

Soil-to-Air Particulate Emission Factor Calculations

Exposure Parameter	Abbreviation	Units	Parameter	References
Area of site	A_{site}	Acres	0.50	Assumed as default (minimum)
Constant	A	-	11.68	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	B	-	23.49	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	C	-	288.00	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Dispersion factor	Q/C	$g/m^2/s$ per kg/m^3	89.03	Calculated according to US EPA (2002) methodology $Q/C = A \times \exp\left[\frac{(\ln A_{site} - B)^2}{C}\right]$
Fraction of vegetative cover	V	Unitless	0.825	Average HILA/HILB default assumptions
Mean annual windspeed	U_m	m/s	6.1	Site specific - Based on the mean 3 pm wind speed recorded at Parafield Airport (BoM Station no. 023013) between 1939 and 2010
Equivalent threshold value	U_t	m/s	7.2	ASC NEPM, Schedule B8; default as per UK EA (2009)
Constant	x	Unitless	1.0	Constant from Cowherd *et al.* (1985) $x = 0.886 \frac{U_t}{U_m}$
Windspeed distribution function	F_x	Unitless	1.308	Calculated according to ASC NEPM $F_x = 0.18 \times (8x^3 + 12x)\exp(-x^2)$
Indoor dust loading factor	DL	mg/m^3	0.039	ASC NEPM, Schedule B7; 95th percentile from Australian data (enHealth 2012)
Particulate emission factor outdoor	PEF_o	mg/m^3	6.4E+07	Relates the concentration of respirable dust particles (<10 µm) in the air with wind speed, vegetative cover and the area of the site occupied by exposed soil. Assumes 100% site-derived soil $PEF_o\ (m^3/kg) = \frac{Q/C \times 3600}{0.036 \times (1-V) \times (\frac{U_m}{U_t})^3 \times F_x}$
Particulate emission factor indoor	PEF_i	mg/m^3	2.6E+07	Indoor dust concentrations are assumed to equilibrate with outdoor dust concentrations through building ventilation. Indoor air is also enriched with dust compared to the outdoor environment, due to the movement of dust indoors on clothing, footwear, etc., as described by the indoor dust loading factor (DL) $PEF_i\ (m^3/kg) = \frac{1}{DL \times 10^{-6}}$

Area	Zone 1 (Residential - Medium Density)
Exposure Media	Soil
Receptor Group	Children (2-6 years)
Chemicals of Potential Concern	PFOS+PFHxS

Parameter	Unit	Value	Details	Source
Soil quality inputs				
Concentration in soil (C_s)	**mg/kg**	**3.829**	Maximum concentration in Zone 1	Site-specific
Percentage PFHxS	**%**	**1%**	PFHxS was below the LoR in the majority of Zone 2a soil samples	Site-specific
Risk calculations				
HI_{Total}	-	**7.0E-01**	$HI = \sum HQ_{All\ pathwways}$	Calculated - based on ASC NEPM algorithms
$HQ_{Ingestion}$	-	**7.0E-01**	$HQ_{Pathway} = \frac{Intake_{Pathway}}{TRV\ x\ (100\% - Background)}$	
$HQ_{Inhalation}$	-	**4.3E-04**		
Intake calculations				
$Intake_{Total}$	mg/kg/day	**1.3E-05**	$Intake_{Total} = \sum Intake_{All\ pathways}$	Calculated - based on ASC NEPM algorithms
$Intake_{Ingestion}$	mg/kg/day	**1.3E-05**	$Intake_{Ingestion} = \frac{C_s\ x\ IR_s x\ EF\ x\ ED}{BW\ x\ AT}$	
$Intake_{Inhalation}$	mg/m^3	**2.7E-08**	$Intake_{Inhalation} = \frac{C_s\ x\ \left(\frac{1}{PEF_o}\ x\ ET_o + \frac{1}{PEF_i} x\ TF\ x\ ET_i\right) x\ LF x\ EF\ x\ ED}{AT}$	
Pathway contribution calculations				
$Contribution_{Ingestion}$	%	100%	$Contribution_{Pathway} = \frac{Intake_{Pathway}}{Intake_{\ Total}}\ x\ 100\%$	Calculation
$Contribution_{Inhalation}$	%	0.2%		
General toxicity and exposure inputs				
TRV	mg/kg/day	0.00002	Based on body weight effects in animal reproductive toxicity studies	FSANZ (2017)
$TRV_{Inhalation}$	mg/m^3	0.00007	Calculated based on the TRV and an adult inhaltion rate of 20m^3/day	ASC NEPM
Background	%	10%	Conservative assumption, calculated on the basis dietary concentrations in Europe and serum concentrations in the Australian population	EFSA (2020), FSANZ (2017), Thompson (2010)
Body weight (BW)	kg	19	Mean body weight of children aged 2-6 years.	FSANZ (2017)
Averaging time (AT)	days	2190	Exposure duration x 365 days/yr. Multipled by 24 for inhalation exposures	ASC NEPM
Exposure frequency (EF)	days/yr	365	Daily - permanent resident	NEPC (1999)
Exposure duration (ED)	years	6	Childhood	ASC NEPM
Oral bioavailability (BIO)	-	1	Assumes that ingested PFAS is largely bioaccessible	OEH (2019)
Soil ingestion exposure inputs				
Ingestion rate (IR_s)	mg/day	63	Average daily incidental soil ingestion rate (Average of HIL A/HIL B defaults)	ASC NEPM
Inhalation exposure inputs				
Time Spent Outdoors (ET_o)	hr/day	4	Default value (HIL A)	ASC NEPM
Time Spent Indoors (ET_i)	hr/day	20	Default value (HIL A)	ASC NEPM
Fraction of indoor dust comprised of soil (TF)	-	0.5	Default value	ASC NEPM
Particle emission factor (PEF_o)	m^3/kg	6.4E+07	Calculated	ASC NEPM
Indoor dust factor (PEF_i)	m^3/kg	2.6E+07	Calculated (82.5% building and hardstand)	ASC NEPM
Lung retention factor (LF)	-	0.375	Default value	ASC NEPM

Soil-to-Air Particulate Emission Factor Calculations

Exposure Parameter	Abbreviation	Units	Parameter	References
Area of site	A_{site}	Acres	0.50	Assumed as default (minimum)
Constant	A	-	11.68	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	B	-	23.49	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	C	-	288.00	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Dispersion factor	Q/C	g/m^2/s per kg/m^3	89.03	Calculated according to US EPA (2002) methodology $Q/C = A \times \exp\left[\frac{(\ln A_{site} - B)^2}{C}\right]$
Fraction of vegetative cover	V	Unitless	0.825	Average HILA/HILB default assumptions
Mean annual windspeed	U_m	m/s	6.1	Site specific - Based on the mean 3 pm wind speed recorded at Parafield Airport (BoM Station no. 023013) between 1939 and 2010
Equivalent threshold value	U_t	m/s	7.2	ASC NEPM, Schedule B8; default as per UK EA (2009)
Constant	x	Unitless	1.0	Constant from Cowherd *et al.* (1985) $x = 0.886\frac{U_t}{U_m}$
Windspeed distribution function	F_x	Unitless	1.308	Calculated according to ASC NEPM $F_x = 0.18 \times (8x^3 + 12x)\exp(-x^2)$
Indoor dust loading factor	DL	mg/m^3	0.039	ASC NEPM, Schedule B7; 95th percentile from Australian data (enHealth 2012)
Particulate emission factor outdoor	PEF_o	mg/m^3	6.4E+07	Relates the concentration of respirable dust particles (<10 µm) in the air with wind speed, vegetative cover and the area of the site occupied by exposed soil. Assumes 100% site-derived soil $PEF_o\,(m^3/kg) = \frac{Q/C \times 3600}{0.036 \times (1-V) \times (\frac{U_m}{U_t})^3 \times F_x}$
Particulate emission factor indoor	PEF_i	mg/m^3	2.6E+07	Indoor dust concentrations are assumed to equilibrate with outdoor dust concentrations through building ventilation. Indoor air is also enriched with dust compared to the outdoor environment, due to the movement of dust indoors on clothing, footwear, etc., as described by the indoor dust loading factor (DL) $PEF_i\,(m^3/kg) = \frac{1}{DL \times 10^{-6}}$

Area	Zone 2
Exposure Meda	Soil
Exposure Scenario	Recreational
Receptor Group	Children (2-6 years)
Chemicals of Potential Concern	PFOS+PFHxS

Parameter	Unit	Value	Details	Source
Soil quality inputs				
Concentration in soil (C_s)	**mg/kg**	**3.89**	Maximum concentration in Zone 1 (SS10)	Site-specific
Percentage PFHxS	**%**	**1%**	PFHxS was below the LoR in the majority of Zone 2a soil samples	Site-specific
Risk calculations				
HI_{Total}	-	**5.7E-01**	$HI = \sum HQ_{All\ pathwways}$	Calculated - based on ASC NEPM algorithms
$HQ_{Ingestion}$	-	**5.7E-01**	$HQ_{Pathway} = \frac{Intake_{Pathway}}{TRV\ x\ (100\% - Background)}$	
$HQ_{Inhalation}$	-	**1.7E-04**		
Intake calculations				
$Intake_{Total}$	mg/kg/day	**1.0E-05**	$Intake_{Total} = \sum Intake_{All\ pathways}$	Calculated - based on ASC NEPM algorithms
$Intake_{Ingestion}$	mg/kg/day	**1.0E-05**	$Intake_{Ingestion} = \frac{C_s\ x\ IR_s x\ EF\ x\ ED}{BW\ x\ AT}$	
$Intake_{Inhalation}$	mg/m^3	**1.1E-08**	$Intake_{Inhalation} = \frac{C_s\ x\ \left(\frac{1}{PEF_o}\ x\ ET_o + \frac{1}{PEF_i} x\ TF\ x\ ET_i\right) x\ LFx\ EF\ x\ ED}{AT}$	
Pathway contribution calculations				
$Contribution_{Ingestion}$	%	100%	$Contribution_{Pathway} = \frac{Intake_{Pathway}}{Intake_{Total}}\ x\ 100\%$	Calculation
$Contribution_{Inhalation}$	%	0.106%		
General toxicity and exposure inputs				
TRV	mg/kg/day	0.00002	Based on body weight effects in animal reproductive toxicity studies	FSANZ (2017)
$TRV_{Inhalation}$	mg/m^3	0.00007	Calculated based on the TRV and an adult inhaltion rate of 20m^3/day	ASC NEPM
Background	%	10%	Conservative assumption, calculated on the basis dietary concentrations in Europe and serum concentrations in the Australian population	EFSA (2020), FSANZ (2017), Thompson (2010)
Body weight (BW)	kg	19	Mean body weight of children aged 2-6 years.	FSANZ (2017)
Averaging time (AT)	days	2190	Exposure duration x 365 days/yr. Multipled by 24 for inhalation exposures	ASC NEPM
Exposure frequency (EF)	days/yr	365	Daily - permanent resident	NEPC (1999)
Exposure duration (ED)	years	6	Childhood	ASC NEPM
Oral bioavailability (BIO)	-	1	Assumes that ingested PFAS is largely bioaccessible	OEH (2019)
Soil ingestion exposure inputs				
Ingestion rate (IR_s)	mg/day	50	Average daily incidental soil ingestion rate	ASC NEPM
Inhalation exposure inputs				
Time Spent Outdoors (ET_o)	hr/day	2	Default value	ASC NEPM
Time Spent Indoors (ET_i)	hr/day	0	Default value	ASC NEPM
Particle emission factor (PEF_o)	m^3/kg	1.1E+07	Calculated	ASC NEPM
Indoor dust factor (PEF_i)	m^3/kg	2.6E+07	Calculated	ASC NEPM
Lung retention factor (LF)	-	0.375	Default value	ASC NEPM
Fruit and vegetable consumption exposure inputs				
Fraction produced in impacted soil ($F_{IGarden}$)	%	100%	Site specific assumption - assumes that the produce garden has the maximum PFOS+PFHxS concentration reported in Zone 2a	Assumption
Fraction of homegrown produce (F_{HG_Garden})	%	5%	Standard assumption for low density residential settings	Assumption
Concentration in green vegetables ($C_{GreenVeg}$)	mg/kg	8.2E-01	$C_{Produce} = TF_{Produce}\ x\ C_s\ x\ F_{IGarden}$	OEH (2019)
Concentration in root vegetables ($C_{RootVeg}$)	mg/kg	5.4E-01		OEH (2019)
Concentration in tuber vegetables ($C_{TuberVeg}$)	mg/kg	2.1E-01		OEH (2019)
Concentration in fruit (C_{Fruit})	mg/kg	6.2E-02		OEH (2019)
Green vegetable consumption rate ($C_{GreenVeg}$)	kg/day	5.5E-02	Mean total fruit and vegetable consumption rates reported for the Australian population (2-6 years)	OEH (2019)
Root vegetable consumption rate ($C_{RootVeg}$)	kg/day	1.7E-02		
Tuber vegetable consumption rate ($C_{TuberVeg}$)	kg/day	2.8E-02		
Fruit consumption rate ($C_{FruitVeg}$)	kg/day	1.8E-01		
Transfer to green vegetables ($TF_{GreenVeg}$)	-	0.21	The maximum wet weight transfer factor for each produce category in soil. The PFOS+PFHxS transfer factor reflects the proportion of PFHxS in water and a multiplier of 6.9	OEH (2019)
Transfer to root vegetables ($TF_{RootVeg}$)	-	0.05		OEH (2019)
Transfer to tuber vegetables ($TF_{TuberVeg}$)	-	0.14		OEH (2019)
Transfer to fruits (TF_{Fruit})	-	0.02		PFAS NEMP 3.0

Soil-to-Air Particulate Emission Factor Calculations

Exposure Parameter	Abbreviation	Units	Parameter	References
Area of site	A_{site}	Acres	0.50	Assumed as default (minimum)
Constant	A	-	11.68	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	B	-	23.49	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Constant	C	-	288.00	US EPA (2002); default value for the assessment of fugitive dust emissions at small sites
Dispersion factor	Q/C	g/m²/s per kg/m³	89.03	Calculated according to US EPA (2002) methodology $Q/C = A \times \exp\left[\frac{(\ln A_{site} - B)^2}{C}\right]$
Fraction of vegetative cover	V	Unitless	0	ASC NEPM default assumption
Mean annual windspeed	U_m	m/s	6.1	Site specific - Based on the mean 3 pm wind speed recorded at Parafield Airport (BoM Station no. 023013) between 1939 and 2010
Equivalent threshold value	U_t	m/s	7.2	ASC NEPM, Schedule B8; default as per UK EA (2009)
Constant	x	Unitless	1.0	Constant from Cowherd *et al.* (1985) $x = 0.886 \frac{U_t}{U_m}$
Windspeed distribution function	F_x	Unitless	1.308	Calculated according to ASC NEPM $F_x = 0.18 \times (8x^3 + 12x)\exp(-x^2)$
Indoor dust loading factor	DL	mg/m³	0.039	ASC NEPM, Schedule B7; 95th percentile from Australian data (enHealth 2012)
Particulate emission factor outdoor	PEF_o	mg/m³	1.1E+07	Relates the concentration of respirable dust particles (<10 µm) in the air with wind speed, vegetative cover and the area of the site occupied by exposed soil. Assumes 100% site-derived soil $PEF_o\,(m^3/kg) = \frac{Q/C \times 3600}{0.036 \times (1-V) \times (\frac{U_m}{U_t})^3 \times F_x}$
Particulate emission factor indoor	PEF_i	mg/m³	2.6E+07	Indoor dust concentrations are assumed to equilibrate with outdoor dust concentrations through building ventilation. Indoor air is also enriched with dust compared to the outdoor environment, due to the movement of dust indoors on clothing, footwear, etc., as described by the indoor dust loading factor (DL) $PEF_i\,(m^3/kg) = \frac{1}{DL \times 10^{-6}}$

Appendix F

Ecological receptor identification

F-1 Introduction

The receptor identification process focuses on identifying the species that may be at risk and the ecological values that need to be protected (NEPC, 1999).

F-1-1 Legislative framework

In South Australia, Federal and State Government legislation that protects ecological communities, flora, and fauna, includes:

- The EPBC Act is the Federal Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places, which are defined in the EPBC Act as Matters of National Environmental Significance (MNES).
  - This database[4] contains data on the distribution of species related to the EPBC Act. The distributions are produced by ecologists in the Department using modelling software and environmental data to map the known and predicted areas of occurrence of EPBC Act listed species and habitat. The EPBC Act is administered by the Department of Climate Change, Energy, the Environment and Water (DCCEEW).
- The *Native Vegetation Act 1991*, which provides protection for native vegetation in South Australia from small ground covers and native grasses to large trees and water plants.
- *Landscape South Australia Act 2019* that protects biodiversity, the resources on which plants and wildlife depend on, and control activities that threaten them.
- *Fisheries Management Act 2007*, which controls conservation and management of the aquatic resources of South Australia including aquatic habitats, aquatic mammals, and exotic organisms.
- *Environment Protection (Water Quality) Policy 2015* provides a framework for managing protection of South Australian waters.

F-1-2 Data sources

The ecological receptors relevant to the Investigation Area and its surroundings have been identified based on observations made in the field and on government managed databases and tools. Table G.8.2 presents the published information sources utilised in this assessment.

Table G.8.2 Desktop information sources

Aspect	Information source
Aquatic ecosystem	*WaterConnect* and *Enviro Data SA* databases provided by the Government of South Australia (Department for Environment and Water).
Flora and fauna species including species and ecological communities of conservation significance	*NatureMaps* database and other resources provided by South Australia's Department for Environment and Water such as *eFloraSA* *Atlas of Living Australia* (2024)
Matters of National Environmental Significance (MNES)	EPBC Act Protected Matters Search Tool (DCCEEW, 2024)
Investigation Area-specific habitat and biota details	Observations made by GHD environmental scientists during the DSI and supplementary DSI (GHD, 2024; GHD, 2023a).

A search area of along Christie Creek was adopted as part of the databases searches based on the following:

- The search area is significantly wider than the Investigation Area and includes all sampling locations to account for local ecological receptor movements.
- The search area considers both resident species and those that may migrate through or use the Investigation Area seasonally.

[4] https://www.dcceew.gov.au/environment/environmental-information-data/databases-applications/snes. Accessed on 27 March 2024.

The datasets extracted from the online databases including a map showing the location of threatened species are provided in at the end of this appendix.

F-2 Conservation Significant Features

A search of the EPBC Act database identified the following Matters of National Environment Significance within the Investigation Area:

– One listed threatened ecological communities: The endangered Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia; and
– 36 listed threatened species including Australasian Bittern (*Botaurus poiciloptilus*), Sharp-tailed Sandpiper (*Calidris acuminata*), and the Australian Painted Snipe (*Rostratula australis*) that may feed on aquatic insects, crustaceans and molluscs and therefore be indirectly exposed to PFAS in the aquatic environment through the food web.
– 21 listed migratory bird species including species that may feed on freshwater aquatic organisms such as the Common Sandpiper (*Actitis hypoleucos*), Curlew Sandpiper (*Calidris ferruginea),* Eastern Curlew (*Numenius madagascariensis)* and the Common Greenshank (*Tringa nebularia*).

Additionally, the following was also reported within a buffer area of 5 km from the site:

– One listed threatened ecological communities: The vulnerable Suptropical and Temperate Coastal Saltmarsh
– 71 listed threatened species (including those listed above)
– 42 listed migratory bird species (including those listed above).

The search did not identify any area listed under the Matters of National Environment Significance such as Ramsar wetlands.

F-3 Environmental features of the Investigation Area

Photographs and descriptions of the Investigation Area are provided in Section 2.2.

F-3-1 Terrestrial environments (Zones 1 and 2)

The site (Zone 1) is located within a developed urban setting. Surrounding areas include residential, commercial/industrial, and open spaces (including Zone 2).

The terrestrial environment in Zone 1 (in the context of the future redevelopment) will likely be predominantly cleared of vegetation aside from potentially small areas of grass and garden beds. Substantial portions of these areas will be covered with buildings, carparks, and various infrastructure. GHD understands that some vegetation may be retained or planted in the development. Overall, Zone 1 is unlikely to provide structural habitats for valuable species.

The terrestrial environment in Zone 2 is partially landscaped with mulched areas and mowed grassed with some scattered young and mature trees, and shrubs. This zone is significantly disturbed by human activity, particularly due to heavy traffic from Flaxmill Road, a major thoroughfare.

Terrestrial fauna

An EPBC Act Protected Matters Report (refer to the end of this appendix) indicates the potential presence of a range of vulnerable, endangered and critically endangered terrestrial communities and species which may be present in the Zone 1 and 2. They include:

– One threatened ecological community - The endangered Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia.
– Listed threatened species
  - Two mammals – the Southern Brown Bandicoot (*Isoodon obesulus*) and the Grey-headed Flying-fox (*Pteropus poliocephalus*).
  - Several bird species (refer to the Section F-2 and end of this appendix)

However, given the land use, limited vegetation and water sources in Zone 1 and 2, these areas are unlikely to support complex ecosystems and stable populations of mammals and birds (there were no terrestrial reptile species listed). Furthermore, no terrestrial species are recorded within Zone 1 and Zone 2 in the NatureMaps and Atlas of Living Australia databases.

F-3-2 Aquatic environment – Christie Creek (Zone 3)

Water quality and external stressors

Surface water samples were collected from within Christie Creek on 12 April 2024, during dry conditions, and 11 July 2024, following a rainfall event. Key results were as follows:

– Electrical conductivity values ranged from 204.5 to 412.6 µS/cm during wet conditions and 2098 to 4406 µS/cm during dry conditions. The water was well oxygenated (dissolved oxygen ranging from 9.3 to 10.8 mg/L[5] during wet conditions and 2.85 to 6.73 mg/L during dry conditions) and had low to moderate turbidity.
– Concentrations of ammonia (up to 1.3 mg/L at SW04) exceeded the ANZG (2018) criterion for the protection of 95% of freshwater species (refer to Table 3b in Appendix B).
– Some concentrations of filtered copper and zinc exceeded the ANZG (2018) criteria for protecting 95% of freshwater species (refer to Table 3b in Appendix B for details).

Aquatic flora

The instream habitat along Christie Creek consisted predominately of pools and shallow and deep riffles/runs that contained woody debris, overhanging vegetation and some emergent macrophytes.

The riparian zone along Christie Creek primarily consists of eucalyptus species, grasses and reeds *(Phragmites sp.).* There are some weeds, including feral olive trees *(Olea europaea* subsp. *europaea),* date palm and pine trees.

The terrestrial vegetation associated with Christie Creek in the vicinity of the Investigation Area is dominated by large native trees, some exotic species and grassed reserves. Within the Investigation Area, there are areas of vegetation that are likely to provide nesting or foraging habitat for woodland bird species and reptiles. However, there are also sections of steep gradients creating narrow drainage corridors and sections near busy roadways that would be less likely to provide appropriate nesting and foraging habitats.

Erosion of the creek banks is apparent within the Investigation Area, most likely due to high surface water flow following heavy rainfall events and subsequent stormwater discharges from upstream areas. The creek channel has been altered in some areas to manage erosion by the installation of rock gabions.

General aquatic fauna

The following species were observed by a GHD senior ecologist along Christie Creek within the Investigation Area:

– White-faced Heron (*Egretta novaehollandiae*)
– Little Pied Cormorant (*Microcarbo melanoleucos*)
– Hoary-headed Grebe (*Poliocephalus poliocephalus*)

[5] Excluding equipment error of 20.8 mg/L at SW09 during 11 July 2024.

Based on the NatureMaps database, some aquatic species have been identified along Christie Creek within the Investigation Area. The following species are of interest:

– Frogs including the common froglet (*Crinia signifera*), banjo frog (*Limnodynastes dumerilii*), spotted marsh frog (*Limnodynastes tasmaniensis*).
– State endangered and vulnerable waterbirds such as the Freckled Duck *(Stictonetta naevosa)*.

A review of the Atlas of Living Australia (2024) database did not show records for fish in Christie Creek within the Investigation Area and limited number of amphibians, including common froglet (*Crinia signifera*), spotted marsh frog (*Limnodynastes tasmaniensis*) and eastern banjo frog *(Limnodynastes dumerilii)*. Various bird species have been recorded along Christie Creek, including species that may feed on aquatic macroinvertebrates, amphibians and small-sized fish (if present) include the little pied cormorant (*Microcarbo melanoleucos),* white-faced Heron (*Egretta novaehollandiae*), and hoary-headed grebe (*Poliocephalus poliocephalus).* No fish or large macroinvertebrates were observed during the GHD inspection.

Mammals recorded within the Investigation Area along Christie Creek included non-native species of foxes and black rats. There is also one record of a western grey kangaroo (*Macropus fuliginosus*), a koala (*Phascolarctos cinereus*), a chocolate wattled bat (*Chalinolobus morio)* and a possum (*Trichosurus vulpecula*) downstream near Christie Creek, within the suburb of Christie Beach, however the urban land use of the suburb is unlikely to support stable populations of kangaroos and koalas.

An EPBC Act Protected Matters Report search (refer to the end of this appendix) indicates the potential presence of a range of vulnerable, endangered and critically endangered species which may be present near the Investigation Area. They include:

– Various water birds – Curlew Sandpiper *(Calidris ferruginea),* Australasian Bittern (*Botaurus poiciloptilus),* Sharp-tailed Sandpiper (*Calidris acuminata),* Australian Fairy Tern (*Sternula nereis nereis*), and the Australian Painted Snipe (*Rostratula australis*).
– Terrestrial mammals – the Southern Brown Bandicoot (*Isoodon obesulus*) and the Grey-headed Flying-fox (*Pteropus poliocephalus*).
– The remainder of the species listed within the EPBC Act Protected Matters Report for the area surrounding the Investigation Area were typically migratory species and plants.

From the database review and site survey, the key receptors within Christie Creek appear to be frogs and water birds as well as potentially fish. However, Christie Creek is an aquatic system that has had the flow modified and surrounding environment anthropogenically disturbed. Modifying the natural flow of rivers by installing dams and weirs and cement banks inhibits fish from migrating and can starve important habitats of water they need to thrive. This also impacts upper trophic level species, such as water birds, by limiting food resources (i.e., fish and other large aquatic species) and the quality of their habitats in Christie Creek.

There were large numbers of invasive species present along the creek, with limited native vegetation remaining which impacts the system as a whole. A lack of native vegetation results in reduced habitat for native species and erosion along the banks. The creek is also likely to be impacted by nutrient and pollution run-off from surrounding industry which can make the area uninhabitable.

Table 1 Christies Creek Sampling Location Habitat Descriptions

Site	Habitat Description	Observations	Photo
Christies Creek, upstream of stormwater discharge from MFS site			
SW08	**Channel pattern:** mildly sinuous **Mode wetted width:** 2 m **Mode Depth:** 1 – 2 m **Water level:** moderate – at watermark **Flow type:** constant (increased due to rain event) **Flow conditions:** average flow **Substrate:** gravel, sand, and silt/clay **In-stream habitat:** shallow pool, runs **Bank stability:** moderate **Bank erosion:** some **Adjacent land use:** public access / recreation **Key water quality parameters:** pH – 8.6 EC – 204.5 µm/cm Dissolved Oxygen – 10.8 mg/L	**Species observed:** No EPBC or State listed species were observed, but species with potential to occur in this habitat from desktop searches include: – Common brushtail possum (NP&W – Rare) – Musk Duck (NP&W – Rare) – Freckled Duck (NP&W – Vulnerable) **Observations:** ***Instream habitat***: Pools and runs with small and large woody debris and overhanging vegetation. ***The riparian zone***: Eucalyptus species and the common reed *(Phragmites australis),* with a lack of mid-storey and under-storey plants present. ***Terrestrial habitat***: A mix of large native trees, some exotic species and grassed reserve, with potential to support bird species and possibly reptiles. A walking track for recreational users nearby that follows the creek. No fish or large macroinvertebrates were observed, likely due to the lack of structural habitat required by these taxa.	

Site	Habitat Description	Observations	Photo
SW09	**Channel pattern:** sinuous **Mode wetted width:** 4 m **Mode Depth:** 1-2 m **Water level:** average, at watermark **Flow type:** constant (increased due to rain event) **Flow conditions:** fast flowing **Substrate:** bedrock, boulders, gravel and sand **In-stream habitat:** riffles, runs **Bank stability:** moderate **Bank erosion:** little **Adjacent land use:** public access / recreation **Key water quality parameters:** pH – 8.44 EC – 235.2 µm/cm Dissolved Oxygen – 20.8 mg/L	**Species observed:** – New Holland Honeyeater – Welcome Swallow No EPBC or State listed species were observed, but species with potential to occur in this habitat from desktop searches include: – Common brushtail possum (NP&W – Rare) – Australasian Darter (NP&W – Rare) **Observations:** ***Instream habitat:*** Shallow and deep riffles/runs with small pools, overhanging vegetation and semi-submerged trees in the water. ***Riparian zone:*** Mature eucalyptus trees, grass and reeds *(Phragmites sp.)* and numerous feral olive trees *(Olea europaea* subsp. *europaea).* ***Terrestrial habitat:*** Steep gradient with rocky outcrops creating a narrow corridor surrounding the creek. Vegetation is a mix of shrubs, larger native and exotic tree species and a grassed reserve further out. A revegetation planting area with native species is uphill of the creek which will provide more native vegetation and habitat in future. A walking track for recreational users follows the creek. No fish or large macroinvertebrates were observed, but the variable substrate and presence of debris in the channel suggest potential habitat for these taxa. This site could support nesting or foraging for bird species and the rock face on the left of the creek can provide habitat for small reptiles.	

Site	Habitat Description	Observations	Photo
Christies Creek, downstream of stormwater discharge from MFS site			
SW10	**Channel pattern:** straight **Mode wetted width:** 5 m **Mode Depth:** 1-2 m **Water level:** average, at watermark **Flow type:** constant (increased due to rain event) **Flow conditions:** moderate flow **Substrate:** Boulders, gravel, sand, and silt/clay **In-stream habitat:** riffles, pools, runs **Bank stability:** moderate **Bank erosion:** some **Adjacent land use:** public access / recreation **Key water quality parameters:** pH – 7.80 EC – 337.5 µm/cm Dissolved oxygen – 9.3 mg/L	**Species observed:** – White-faced Heron – Little Pied Cormorant No EPBC or State listed species were observed, but species with potential to occur in this habitat from desktop searches include: – Eastern Cattle Egret (NP&W – Rare) **Observations:** ***Instream habitat***: Riffles and runs with slow moving pools, small woody debris and emergent macrophytes. There is a semi-submerged pipeline crossing the channel creating a step. ***Riparian zone***: Mature and young eucalyptus, shrubby acacias, reeds and grasses. ***Terrestrial habitat:*** Large native trees and shrubs, with one side stretching out into a large, grassed reserve. The other side is close to a road. Due to the traffic, this site may be less likely to provide nesting or foraging habitat for woodland bird species and reptiles. A walking track for recreational users follows the creek. No fish or large macroinvertebrates were observed, but the variable substrate in the channel suggests potential habitat for these taxa. Some larger waterbirds were seen, and it is likely this section of the creek would provide habitat and resources for birds and other aquatic species such as amphibians and reptiles.	 

Site	Habitat Description	Observations	Photo
SW11	**Channel pattern:** sinuous **Mode wetted width:** 5 m **Mode Depth:** 1-2 m **Water level:** low, < watermark **Flow type:** constant (increased due to rain event) **Flow conditions:** fast flowing **Substrate:** Boulders, gravel and silt/clay **In-stream habitat** riffles, runs **Bank stability:** moderate **Bank erosion:** low **Adjacent land use:** public access /recreation **Key water quality parameters:** pH – 7.75 EC – 287.5 µm/cm Dissolved oxygen – 9.97 mg/L	**Species observed:** No EPBC or State listed species were observed, but species with potential to occur in this habitat from desktop searches include: – Australasian Darter (NP&W – Rare) – Black-chinned Honeyeater (NP&W – Vulnerable) **Observations:** ***Instream habitat***: Fast flowing riffles and runs, with large boulders and some emergent macrophytes. ***Riparian zone***: Mature eucalyptus trees, saplings, *Callitris trees*, and *Lomandra*s grass species observed close to the channel edge. **Terrestrial habitat:** Large native trees and shrubs largely open, hence, less likely to support bird and reptile species. Steep gradient with rocky outcrops near the creek may cause drainage corridor into the creek. A walking track for recreational users runs alongside the creek. with a pedestrian bridge and a main road. No fish or large macroinvertebrates were observed, but variable substrate in the channel suggest potential habitat for these taxa. While no other large vertebrate species were observed, this section of the creek likely support amphibians and various terrestrial, semi-aquatic and aquatic birds, mammals and reptiles.	

Site	Habitat Description	Observations	Photo
SW12	**Channel pattern:** **Mode wetted width:** 7 m **Mode Depth:** 1-2 m **Water level:** average, at watermark **Flow type:** constant (increased due to rain event) **Flow conditions:** fast flowing **Substrate:** Cobbles, gravel, sand and silt/clay **In-stream habitat:** steps, riffles and pools **Bank stability:** good **Bank erosion:** some **Adjacent land use:** public access /recreation **Key water quality parameters:** pH – 7.88 EC – 325.3 µm/cm Dissolved oxygen – 10.3 mg/L	**Species observed:** No EPBC or State listed species were observed, but species with potential to occur in this habitat from desktop searches include: – Musk Duck (NP&W – Rare) – Australasian Bittern (EPBC – Endangered) **Observations:** ***Instream habitat***: Emergent macrophytes beds and large woody debris present around steps creating riffles and runs. ***Riparian habitat:*** Eucalyptus trees, casuarinas, and reeds. Erosion management used at both edges of the channel. ***Terrestrial habitat***: The northern side of the creek is fenced (i.e. to a primary school), while the southern side is composed by large native trees and shrubs, but largely open and modified as a grassed reserve, hence, unlikely to support birds and reptiles species. A walking track for recreational users including a pedestrian bridge runs alongside the creek. While no fish or large macroinvertebrates were observed, this site is likely to provide good habitat for macroinvertebrate species due to variation is substrate in the channel, and large amounts of emergent vegetation. While no other large vertebrate species were observed, this section of the creek likely support amphibians and a various terrestrial, semi-aquatic and aquatic birds, mammals and reptiles.	

Site	Habitat Description	Observations	Photo
SW13	**Channel pattern:** mildly sinuous **Mode wetted width:** 8 m **Mode Depth:** 1-2 m **Water level:** low, < watermark **Flow type:** constant (increased due to rain event) **Flow conditions:** fast flowing **Substrate:** bedrock, boulders, cobbles and sand **In-stream habitat:** steps, riffles and runs **Bank stability:** good **Bank erosion:** some **Adjacent land use:** public access /recreation **Key water quality parameters:** pH – 7.69 EC – 387.2 µm/cm Dissolved oxygen – 9.87 mg/L	**Species observed:** No EPBC or State listed species were observed, but species with potential to occur in this habitat from desktop searches include: – Painted Honeyeater (NP&W – Rare, EPBC – Vulnerable) **Observations:** ***Instream habitat:*** Emergent macrophytes beds and large woody debris present around rocks creating riffles and runs. ***Riparian habitat:*** Eucalyptus trees reeds and several invasive species including date palm, olives and pine trees. Erosion management is in place at both edges of the channel. ***Terrestrial habitat***: Steep gradient forming a narrow drainage corridor with vegetation consistent on large trees, shrubs, and invasive species, hence, unlikely to support bird and reptile species. A walking track is uphill off the creek with a road and housing beyond it. While no fish or large macroinvertebrates were observed, the site is likely to provide good habitat for these taxa due to substrate variation and emergent vegetation present in the channel. No other large vertebrate species were observed during the survey, likely due to less optimal habitat for aquatic species compared to native vegetation.	

Site	Habitat Description	Observations	Photo
SW14	**Channel pattern:** wide and straight **Mode wetted width:** 11 m **Mode Depth:** 0-1 m **Water level:** low, < watermark **Flow type:** permanent estuarine **Flow conditions:** moderate **Substrate:** bedrock, boulders, gravel, and sand **In-stream habitat:** runs and pools **Bank stability:** moderate **Bank erosion:** some **Adjacent land use:** public access /recreation **Key water quality parameters:** pH – 7.84 EC – 412.6 µm/cm Dissolved oxygen – 10.33 mg/L	**Species observed:** – Hoary-headed Grebe No EPBC or State listed species were observed, but species with potential to occur in this habitat from desktop searches include: – Common Sandpiper (NP&W – Rare) – Curlew Sandpiper (EPBC – Critically Endangered, NP&W – Endangered) **Observations:** ***In stream habitat***: Shallow and deep pools and runs with various substrates including bedrock, boulders, gravel and sand. At the time of surveying the beach was at low tide. ***Riparian habitat***: Shrubby acacias, tea trees *(Leptospermum), Lomandras* and other grass species. ***Terrestrial habitat:*** Steep gradient of rocky outcrops creating a narrow drainage corridor. The vegetation was primarily mid-sized shrubs and grasses before turning into toads and housing. This habitat likely supports shorebird and reptile species. At this site, the creek meets the sand of Christie's Beach, which is used for recreational purposes. No fish or large macroinvertebrates were observed, but this site is likely to provide good habitat for macroinvertebrate species due to sand beds and variation in substrate in the channel. One water bird was observed, but no other large vertebrates. However, this habitat could support various aquatic and semi-aquatic species including small fish, birds, mammals and reptiles due to its proximity to the ocean and varied substrate