



Site Management Plan/Groundwater Monitoring Management Plan

Largs North Fire Station

South Australian Metropolitan Fire Service

16 August 2022



→ **The Power of Commitment**

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Executive Summary

The South Australian Metropolitan Fire Service (MFS) have used firefighting foam containing per- and poly-fluoroalkyl substances (PFAS), historically at the Largs North Fire Station (the site) up until 2016. The foam was used during the testing of delivery systems on firefighting appliances.

This combined Site Management Plan (SMP) and Groundwater Monitoring Management Plan (GMMP) (SMP/GMMP) has been prepared to implement the recommendations of the Remediation Options Assessment (ROA, GHD, 2021a) to address PFAS in soil and groundwater beneath the MFS Largs North station and in groundwater beneath residential properties to the north of the site.

This SMP/GMMP is subject to, and must be read in conjunction with, the limitations set out in Section 1.4 and the assumptions and qualifications contained throughout the SMP/GMMP.

Background

Since December 2018, a number of environmental investigations have identified PFAS impacts in dust, soil, concrete paving, fruit, eggs and foliage on-site and in groundwater both on- and off-site. The MFS submitted a Voluntary Site Contamination Assessment Proposal (VSCAP) for the site dated 30 October 2019 to the South Australian Environment Protection Authority (SA EPA) and undertook remedial actions at the site. These included the removal and disposal of chickens, eggs, site vegetation (fruit trees, ornamental trees and shrubs) and fruit stored on site; covering accessible soil with geotextile fabric and mulch barriers; cleaning the air conditioning system and replacement of most ducts.

The purpose of this SMP/GMMP is to document the ongoing management of identified PFAS impacts to soil and groundwater at the site to ensure that no unacceptable risk to human health or ecological receptors exist under the continued commercial/industrial land use.

Scope of work

The SMP provides information about:

- The nature and location of residual impacts.
- How these impacts are to be managed to adequately protect human health and the environment.
- The parties responsible for implementation of this plan.
- Contingency measures.

The GMMP outlines the details for the following:

- Details of the sampling and testing requirements for the existing on-site and off-site groundwater wells.
- Timeframe over which monitoring will take place, i.e. annual groundwater monitoring events (GMEs) over two years (i.e. April 2022 and April 2023), subject to the auditor's approval.
- Timeframes for reports to be submitted to the auditor and the SA EPA.
- Timeframes for community engagement to be undertaken as part of the GMMP.
- A contingency plan, should the management and monitoring measures not be successful.
- Triggers for GMMP review and cessation.

Summary of risks

Site investigations undertaken to date have identified the following potential risks to human health:

- ingestion of, or direct contact with PFAS impacted groundwater by future off-site users.
- consuming fruit and vegetables either irrigated by PFAS impacted groundwater or grown in soil where roots may interact with PFAS impacted groundwater.

Risks to environmental receptors were considered acceptable. Marine water at a 95% species protection level was identified as the most sensitive environmental value.

Remediation goals and objectives

Three remediation goals were considered for this site as per the ROA.

- Remediate (treat, contain, remove or manage) PFAS impacted media at the site to restore the environmental value(s) of groundwater.
- Mitigate ongoing harm to groundwater or other environmental harm to the extent practicable.
- Eliminate or prevent harm to human health.

Remediation objectives include:

- Addressing the source area/s to limit their contribution to the identified dissolved groundwater plume emanating from the site.
- Preventing further migration of the PFAS impacts in groundwater associated with past operations at the site beyond their current extent.
- Informing the community and the future owners and occupants of the site of the risks posed by the identified PFAS impacts.

Summary of remediation conclusions and recommendations

For residual PFAS in soil, no active remedial measures were implemented based on the relatively high cost of undertaking stabilisation/immobilisation having no net benefit with regards to changing an already acceptable risk profile or reducing ongoing harm to groundwater and the disruption that would be caused to site operations. Engineered controls (barriers) were installed to limit access to impacted soils and prevent the generation of dust. Should increasing PFAS concentrations be identified that result in a change to the risk profile or ongoing harm to groundwater in the future, stabilisation of PFAS in soil or excavation and disposal/containment at a suitable off-site location should be considered.

Monitoring the existing well network, in combination with community engagement in accordance with the SA EPA and VSCAP requirements, was identified as the most practicable option for managing the identified PFAS impacts in groundwater. This approach aims to assess plume stability over time to allow statutory controls to be put in place to limit future use of groundwater. Further monitoring would also ensure that any future PFAS plume migration will be identified and managed appropriately.

An SMP/GMMP was recommended for the implementation of the preferred remediation options and to inform all stakeholders of the necessary steps required to manage the ongoing PFAS issues at the site. The SMP includes the following control measures.

- Ongoing management and maintenance of barriers to prevent access to site soils, and to eliminate potential future dust impacts from PFAS impacted soils.
- Regular inspections and cleaning of the air conditioning system at the fire station (if required).
- Regular cleaning of site surfaces around the fire station, particularly within the kitchen area.
- Ensuring the community is properly informed on risks posed by the PFAS impacts associated with the site and on any control measure to prevent future risk.
- Ensuring the future owners and occupants of the site are properly informed of the risks posed by the PFAS impacts at the site, and how these will be managed to ensure they remain acceptably low.
- Implementation of the Groundwater Monitoring Management Plan (GMMP) to provide a longer-term temporal data set to assess PFAS plume stability.
- Ongoing information and advice regarding groundwater use via community updates/engagement and possibly via institutional controls of water restriction or prohibition area in the future.

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1. Introduction

The South Australian Metropolitan Fire Service (MFS) engaged GHD Pty Ltd (GHD) to prepare a Site Management Plan (SMP) and Groundwater Monitoring Management Plan (GMMP) for the Largs North Fire Station (the site) located on 2-4 Willochra Street, Largs North, SA 5016.

The SMP presents details regarding site locality and description, the extent of contamination, background to previous investigations and monitoring, identification of potential contamination pathways and their receptors, a risk matrix assessment, and a framework for the management of current identified risks including roles and responsibilities. The GMMP presents details on a monitoring plan for the sampling and testing of groundwater wells, including timeframes over which monitoring and reporting will take place.

The site location plan is presented in Figure 1 at the end of this report. The site layout is shown on Figure 2.

1.1 Background

Historically, the MFS used firefighting foam containing per- and poly-fluoroalkyl substances (PFAS) at the site during testing of delivery systems on firefighting appliances. Foam containing PFAS has not been used at Largs North Fire Station since 2016. Since December 2018, environmental investigations have identified PFAS impacts in dust, soil, concrete paving, fruit, eggs and foliage on-site and in groundwater both on- and off-site. The MFS submitted a Voluntary Site Contamination Assessment Proposal (VSCAP) for the site dated 30 October 2019 to the South Australian Environment Protection Authority (SA EPA) and undertook remedial actions at the site. These included removal and disposal of chickens, eggs, site vegetation (fruit trees and ornamental trees and shrubs) and fruit stored on site; covering accessible soil with geotextile fabric and mulch barriers; cleaning the air conditioning system and replacement of most ducts.

The site is being audited by Site Contamination Auditor Steve Kirsanovs, who is accredited in South Australia pursuant to Division 4 of Part 10A of the *Environment Protection Act 1993*, No. 2009020.

Following the completion of a detailed site investigation, including on- and off-site groundwater assessments (GHD, 2019a-c, 2020a-f and 2021b), GHD conducted a remediation options assessment for the site (GHD, 2021a). The MFS is implementing the SMP/GMMP as the preferred remediation option for the site.

1.2 Purpose

The purpose of this SMP/GMMP is to document the required ongoing management of identified PFAS impacts to soil and groundwater at the Largs North Fire Station site to ensure they do not pose an unacceptable risk to human health or ecological receptors under the continuing current commercial/industrial use scenario as a fire station.

1.3 Scope of Work

This SMP/GMMP was prepared by GHD based on previous investigation reports, in particular the Remediation Options Assessment (GHD, 2021a), and with reference to the SA EPA (2019a) Guidelines for the assessment and remediation of site contamination (GAR).

The SMP provides information about:

- The nature and extent of residual impacts
- How these impacts are to be managed to adequately protect human health and the environment
- The parties responsible for implementation of this plan
- Contingency measures.

The GMMP outlines the details for the following:

- Monitoring plan of the sampling and testing of the existing on-site and off-site groundwater wells

- Timeframe over which monitoring will take place, i.e. annual groundwater monitoring events (GMEs) over two years (i.e. April 2022 and April 2023), subject to the auditor's approval
- Timeframes for reports to be submitted to the auditor and the SA EPA
- Timeframes for community engagement to be undertaken as part of the GMMP
- Contingency plan if the management and monitoring measures are not successful
- Triggers for GMMP review and cessation.

1.4 Limitations

This report: has been prepared by GHD for South Australian Metropolitan Fire Service and may only be used and relied on by 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 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. 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 this report on the basis of information provided by South Australian Metropolitan Fire Service and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.5 Community Engagement

The MFS has been and will be engaging with the community as required, in consultation with the auditor and the SA EPA, in accordance with the VSCAP (GHD 2019) and the SA EPA (2018) Site contamination guideline for communication and engagement. Updates provided to the community are an important part of the overall remediation strategy and risk management.

Community engagement undertaken to date was documented and included the following:

- A community drop-in Information session was organised at the MFS Largs North station in December 2018. Representatives of the community, the South Australian Department for Health and Wellbeing (SA Health), SA EPA and the City of Port Adelaide Enfield attended the session.
- Between 2019 and 2020, MFS and GHD representatives have distributed letters to residential properties informing the residents about the PFAS assessment at Largs North and the installation of groundwater monitoring wells on public land in the vicinity of their properties.
- On 1 March 2019, GHD distributed letters to the community informing the community about the elevated PFAS impact in groundwater around the Largs North Fire Station and about further offsite groundwater investigation. The letter informed the residents about the doorknock water use survey to be undertaken in 2019, a dedicated hotline number and provided an on-line survey link to [surveymonkey.com](https://www.surveymonkey.com).
- A doorknock water use survey was undertaken in March - April 2019 to inform residents of the identified presence of PFAS in the groundwater and the requirement to avoid using groundwater as a precaution until further notice. This is consistent with SA Health advice which stated that 'in urban settings and where mains

water is available, the use of shallow bore water for potable and/or other domestic purposes is not recommended'.

- A dedicated hotline number (1800 325 110) was set up to provide an additional option for the community to provide their feedback and questions. The hotline has been monitored during business hours Monday to Friday from 9 am to 5 pm by GHD personnel. Calls to this hotline number are free of charge for residents.
- The survey did not identify any properties with registered or unregistered groundwater bores within the plume extent that were using groundwater for any use, including recreational use. The survey identified the presence of fruit trees planted in open soil at numerous residential properties in the survey area and that the fruit produce was consumed. Fruit testing of both citrus and stone fruit at selected properties within the PFAS plume area, conducted by GHD in February 2020 and reported on in a letter report (GHD 2020b), found that PFAS was not detected in any of the fruit sampled at the selected properties.
- In relation to future investigations, letters will be distributed by GHD representatives to residents informing them about upcoming groundwater investigations in the vicinity of their property.

During the monitoring phase of the project (see GMMP in Section 6) community engagement will be undertaken if further groundwater monitoring identifies an increase in groundwater PFAS concentrations resulting in a change in the level of risk to the identified receptors.

2. Site Information

The MFS owns and operates the site at the corner of Victoria Road and Willochra Street as the Largs North Fire Station. The site is used by MFS employees and visitors to the site.

2.1 Site Identification

Site information details are presented in Table 2.1 below.

Table 2.1 Summary of general site identification information

Site Name:	Largs North Fire Station
Site Address	2-4 Willochra Street, Largs North, SA 5016
Certificate of Title	CT 5441/197
DP and Lot	D7914 A11
Current Zoning	Light Industry
Property Owner	South Australian Metropolitan Fire Service
Current Site Use	Fire Station
Area	3,280 m ²
Site Elevation	3.0 m AHD

A site location plan is provided in Figure 1. It is understood that the MFS will continue to use the site as a fire station.

2.2 Stakeholders and Site Contamination Audit Details

The relevant stakeholders and roles and responsibilities for the ongoing management of the site are presented in Table 2.2 below.

Table 2.2 Relevant stakeholders and their responsibilities

Stakeholder	Responsibilities
Site Owner (current owner of site)	<ul style="list-style-type: none"> – Implement any requirements of the SMP/GMMP. – Ensure any site maintenance personnel or subcontractors who may be required to undertake excavation works at the site, are made aware of, and are provided with, this SMP. – Review and update the SMP, if required, due to identification of material changes to the contamination status of the site. – Ensure purchaser or lessee of the site is made aware of and is provided with this SMP/GMMP.
Sub-contractors (engaged in site redevelopment and ground disturbance works)	<ul style="list-style-type: none"> – Acknowledge the requirements of the SMP. – Prepare an occupational health and safety plan that considers worker exposures to mitigate potential risks associated with residual soil and groundwater contamination beneath the site. The plan should take into consideration any relevant safety management controls specified for the Site Owner's subcontractors engaged to undertake works on-site. – Implement safe working procedures, in accordance with the occupational health and safety plan developed by the subcontractor.
Environmental consultant	<ul style="list-style-type: none"> – Conduct groundwater monitoring as per the GMMP (Section 6). – Prepare groundwater monitoring reports for review by the MFS, the auditor and SA EPA. – Notify the MFS, auditor and SA EPA if contingency measures are triggered.
Site contamination auditor	<ul style="list-style-type: none"> – Review and endorse the SMP/GMMP. – Review the groundwater monitoring reports. – Complete the site contamination audit report (restricted scope)
SA EPA	<ul style="list-style-type: none"> – Maintain regulatory oversight of the site. – Review and maintain copies of all reports pertaining to the site

On behalf of MFS Krystle Mitchell, Senior Scientific and Environment Officer, South Australian Metropolitan Fire Service, 99 Wakefield Street, Adelaide SA 5000 (T: (08) 8204 3714, M: 0407 727 948, Krystle.mitchell@sa.gov.au) requested the SMP/GMMP.

A/ACFO Jeff Swann will be responsible for the implementation of the SMP/GMMP at the site.

MFS appointed an accredited site contamination auditor (Steven Kirsanovs of Kirsas Environmental, No. 2009020) in September 2019. The Auditor has reviewed the investigation reports and will produce a restricted scope site contamination audit report relating to the PFAS contamination at the site, in accordance with the Environment Protection Act 1993 (the Act) and Environmental Protection Regulations 2009 (the Regulations) and the Guidelines for the Site Contamination Audit System (SA EPA, 2019b).

The restricted scope audit will determine the nature, extent and associated risk of PFAS contamination present on or below the surface of the site. The restricted audit will include a statement on the nature and extent of contamination and what remediation remains necessary in respect to PFAS. The Auditor has indicated that the implementation of a SMP will be a condition of the restricted scope site contamination audit report.

2.3 Previous Investigations

The following environmental reports have been previously prepared for the site:

- GHD 2019a, Largs North Station and Gallantry PFAS testing Detailed Site Investigation (DSI) Report for South Australian Metropolitan Fire Service, April 2019
- GHD 2019b, Largs North Station and Gallantry PFAS Testing, Site Groundwater Use Survey & Groundwater Investigation for South Australian Metropolitan Fire Service, 27 May 2019
- GHD 2019c, Largs North Fire Station Draft Preliminary Site Investigation for South Australian Metropolitan Fire Service, 21 November 2019
- GHD 2020a, Largs North Station Groundwater Investigation (October 2019) for South Australian Metropolitan Fire Service, 09 January 2020
- GHD 2020b, Largs North Station and Gallantry PFAS testing, Resident Fruit Testing for South Australian Metropolitan Fire Service, 10 February 2020
- GHD 2020c, Largs North Station Groundwater Investigation (February 2020) for South Australian Metropolitan Fire Service, 21 April 2020
- GHD 2020d, Largs North Station Groundwater PFAS Assessment, Sampling and Analysis Quality Plan (SAQP) (June 2020) for South Australian Metropolitan Fire Service, 24 June 2020
- GHD 2020e, Largs North Station and Gallantry PFAS Testing, Detailed Site Investigation (DSI) – Groundwater Assessment (April 2020) for South Australian Metropolitan Fire Service, June 2020
- GHD 2020f, Largs North Station and Gallantry PFAS Testing, Dust Testing – Post Clean Validation Sampling (June 2020) for South Australian Metropolitan Fire Service, 16 July 2020
- GHD 2021a, Largs North Fire Training Station, Remediation Options Assessment (September 2021) for South Australian Metropolitan Fire Service, 24 September 2021
- GHD 2021b, Largs North Fire Station Groundwater Investigation (April 2021) for South Australian Metropolitan Fire Service, 22 June 2021.

3. Summary of Residual Site Contamination

Previous investigations (refer Section 2.3) identified PFAS impacts in on-site soil and in groundwater on- and off-site. The extent of these impacts, remedial actions taken to-date and the identified residual risks are summarised in the following sections. The assessment criteria adopted for the previous investigations were from the following guideline:

- HEPA (2020) PFAS National Environmental Management Plan (Version 2.0), Heads of Environment Protection Authorities Australia and New Zealand, January 2020, (PFAS NEMP).

3.1 PFAS-impacted Soil

Previous investigations identified the presence of PFAS impacted dust and soil on-site. Shallow garden soil within the southern, western and northern garden areas, including within the former chicken coop, were affected as shown in Figure 3 at the end of this report.

The MFS has undertaken remedial works to limit exposure of PFAS impacted dust and soil to site workers. With regards to soil, this included covering PFAS contaminated accessible soil and shallow soil on-site within the southern, western and northern garden areas with geotextile fabric and mulch barriers. It is also noted that activities such as growing fruit/vegetables and keeping chickens are no longer permitted on MFS sites.

Residual concentrations of PFAS were found on the western boundary around groundwater well MW04, where the highest PFAS concentrations in groundwater were observed. Due to shallow groundwater in well MW04 at approximately 2.6 m below ground level, the PFAS impacted groundwater may impact the local shallow soils. The volume of potentially PFAS-impacted soil, in a 5 m radius around well MW04 to a depth of 2.5 m, is approximately 200 m³, which corresponds to approximately 400 tonnes of soil that may require remediation in the future. However, given this area is covered with asphalt, there is currently no exposure to these soils, subject to maintaining the integrity of the bitumen cover.

It is also noted that residual concentrations of PFAS are present in soil on the southern boundary of the site, at concentrations below the health-based commercial industrial criteria.

3.2 PFAS-impacted Groundwater

In April 2021, PFAS impacts in groundwater extended approximately 200 m to the north along Victoria Road and extended east beneath residential properties in Sheean Street, Collins Street, Waller Court and Rankin Drive (Figure 4 and GHD, 2021b). The concentrations of PFAS in groundwater in this area were generally above drinking water criteria but below recreational criteria. The following are observations on PFAS-impacted groundwater at the site:

- The highest groundwater PFAS concentrations were identified in a localised source-zone around well MW04 (Figure 4) located on the western site boundary, which was associated with historical use of PFAS containing foam and drainage infrastructure beneath the site.
- Investigations to date have identified PFAS in wells located up- and cross-hydraulic gradient of the site, indicating the presence of other off-site PFAS sources, such as the fuel terminal located south and east of the site.

3.3 Summary of Risks

3.3.1 Risks to Human Health

3.3.1.1 Potable Use

The results of the groundwater use survey conducted in March-April 2019 (GHD, 2019b) did not identify any potable use and there has not been any evidence of current groundwater use / extraction in the residential areas north (down-gradient) of the site where PFAS have been detected in groundwater. However, the observed salinity in groundwater, recorded as total dissolved solids (TDS) was variable and, in some instances, below 1,200 mg/L. Therefore, future potable use cannot be ruled out.

Statutory mechanisms such as the declaration of a groundwater prohibition area (GPA) by the SA EPA under the Environment Protection Act 1993 would provide future assurance that the potable use pathway would not become complete in the future.

3.3.1.2 Consumption of PFAS-impacted Produce

The consumption of fruit and vegetables either irrigated by PFAS impacted groundwater or grown in soil where roots may interact with PFAS impacted groundwater has also been identified as a potential risk to human health on- and off-site. As a result of PFAS being detected in fruit and eggs at the fire station, trees and chickens were removed from the site. Testing of fruit grown down-hydraulic gradient of the site did not detect PFAS concentrations above the laboratory's level of reporting (LOR) (GHD, 2020b), indicating that PFAS concentrations in groundwater were not elevated to a level whereby PFAS was accumulating in fruit. Only one data set has been obtained to date and additional data would be required to confirm if this pathway is complete.

3.3.1.3 Direct Contact with Soil

The potential risks associated with direct contact and incidental exposures to PFAS impacted soils have been mitigated by the provision of the barriers over the site soils preventing access and exposure to workers and visitors to the site.

3.3.2 Risks to Ecological Receptors and Environmental Values

Based on the industrial setting of the site and the reported extent of the PFAS plume in groundwater down-gradient of the site, as delineated in April 2021 (GHD, 2021b), there is currently no complete source-pathway-receptor linkage between the site and sensitive receptors. PFAS concentrations in groundwater down-hydraulic gradient of the site, in the direction of ecological receptors such as the Port Adelaide River, were below the nominated ecological criteria. Therefore, the current risk to ecological receptors, including the ecosystem of the Port Adelaide River, is considered acceptable.

To assess the contamination status of groundwater at a site, the SA EPA provided a four-step process to determine the environmental values of groundwater and to determine if actual or potential harm to groundwater, that is not trivial, has occurred. The four-step process is described in the Guidelines for the Assessment and Remediation (GAR) of Site Contamination (SA EPA, 2019a).

Based on this four-step process, the most sensitive environmental value to be applied to the site is marine water (95% species protection level) (GHD, 2021b).

3.3.3 Determination of Harm to Groundwater

Reported PFAS concentrations in groundwater indicate that harm to groundwater has occurred as a result of historical site activities releasing PFAS into the environment.

4. Remediation Options and Issues

4.1 Remediation goals

The Remediation Options Assessment (GHD, 2021a) defined the remediation goals and objectives for the site listed in Table 4.1.

Table 4.1 Remediation goals and objectives and to what extent they have been met

Remediation Goals and Objectives	Extent to which Goals / Objectives have been met
Remediation Goals	
Remediate (treat, contain, remove or manage) PFAS chemical substances at the site to restore the environmental value(s) of groundwater	PFAS impacts in soil have been contained to the extent practicable and will be managed by implementing the SMP.
Mitigate ongoing harm to groundwater or other environmental harm to the extent practicable.	Based on groundwater monitoring results the residual PFAS concentrations in soil are not contributing to ongoing harm to groundwater beyond what has already occurred. No further action required unless conditions change.
Eliminate or prevent harm to human health.	Harm to human health has been eliminated and future harm will be prevented by implementing the SMP.
Remediation Objectives	
Addressing the source area/s to limit the extent which these might continue to feed the dissolved groundwater plume emanating from the site.	Source areas have been addressed to the extent practicable. Ongoing management is required to ensure barriers remain functional.
Preventing further migration of the PFAS impacts in groundwater associated with past operations at the site beyond the current extent.	Stability of plume to be reviewed via a longer-term data set collected as part of ongoing monitoring.
Ongoing management and maintenance of barriers to prevent access to site soils, and to eliminate potential future dust impacts from PFAS impacted soils.	Objective achieved by implementing this SMP.
Ensuring the community is informed of the potential risks posed by the PFAS impacts associated with this site and what else needs to be done to prevent risks in the future.	Objective achieved by implementing this SMP.
Ensuring the future owners and occupants of the site are properly informed on risks posed by the PFAS impacts at the site, and how these need to be managed to ensure risks from the PFAS impacts remain acceptably low in the future.	Objective achieved by implementing this SMP.

The ROA approach included:

- The identification of remedial options that are achievable and practicable using available technologies, with a financial investment commensurate with the risk of harm to the environment, and identification of the most appropriate technology to achieve the remediation goals in this context
- The assessment of the site's constraints
- The identification of PFAS remediation options and technologies applicable to the site based on the constraints assessment, findings of previous environmental assessments and the conceptual site model (csm) (Figure 5)
- The identification of options suitable to either restore the environmental value of groundwater or mitigate ongoing harm to groundwater to the extent practicable
- The selection of the preferred remediation option for the areas of concern.

The assessment evaluated remediation options using multi-criteria-analysis (MCA) with weighted selection criteria including effectiveness (28% weighting), costs (28%), maturity of the technology (16%), the residual liability to the MFS (13%), complexity to implement (8%) and transport and logistics requirements (8%).

4.2 Soil

The ROA assessed the following five remediation options for on-site soil with residual PFAS impacts:

- Do nothing (business as usual)
- RemBind® treatment and retaining on-site
- Transport and treatment at SOLVE facility, Victoria
- Transport to and disposal at Sandy Ridge geological repository, Western Australia
- Incineration at RENEX, Victoria.

The assessment took the following site constraints into consideration:

- Currently there is no landfill in South Australia licenced to accept PFAS impacted soil.
- Access to potentially impacted soil around well MW04 is restricted by a bitumen cover and the contaminant mass of PFAS within the soil is very low based on the low volume of approximately ~400 tonnes.
- Residual PFAS concentrations in soil on the southern boundary were below the health-based assessment criteria for commercial / industrial land use and the mass of PFAS contained in this soil was relatively small so that remediation of this soil is not warranted.
- Groundwater monitoring to date has indicated PFAS concentrations in groundwater beneath the MFS site and down-hydraulic gradient of the site is generally stable, indicating the residual concentrations of PFAS in soil are not contributing to ongoing harm to groundwater beyond what has already occurred.
- The MFS has previously undertaken extensive remedial works to limit exposure of PFAS impacted dust and soil to site workers. This included covering PFAS impacted accessible soil with geotextile fabric and mulch barriers particularly within the southern, western and northern garden areas. In turn, it is crucial that the integrity of the geotextile and mulch barriers is maintained as part of the SMP. Other remedial works included cleaning the air conditioning system and replacement of most ducts. Temporary or long-term storage of PFAS impacted soil on-site or on-site treatment and reinstatement would unlikely be accepted by MFS staff or the United Firefighters Union. Onsite remedial works would also impact on station operations while these works were undertaken.

Based on the MCA “do nothing / business as usual” was the preferred option followed by RemBind® treatment. The selection of the option was based on the following rationale:

- The residual concentrations of PFAS in soil are not contributing to ongoing harm to groundwater beyond what has already occurred.
- The residual PFAS concentrations in soil do not pose an unacceptable risk to site users and the MFS has undertaken remedial works to remove any source receptor linkage at the site.
- Remedial works would impact on site operability.
- Remedial works could exacerbate a perceived risk of PFAS exposure by site users, which was previously observed when the issue was initially identified.
- Remedial works would incur a high cost to remove a small amount of contaminant mass.

In the instance that PFAS in groundwater conditions were to change in the future, stabilisation of PFAS in soil with RemBind® (a powdered adsorbent that binds strongly to PFAS in soil, preventing it from leaching into groundwater) could be considered as a response remedial option. Alternatively, the option to remove and dispose PFAS impacted soil locally should be investigated if it becomes available in the future.

4.3 Groundwater

The ROA assessed the following four remediation options for on-site soil with residual PFAS impacts:

- Do nothing (business as usual)
- Groundwater monitoring and community engagement (as required)
- Removal of PFAS source, groundwater monitoring and community engagement.
- Treatment with in-situ chemical oxidation
- Pump and treat with reverse osmosis
- Pump and treat with granular activated carbon

The assessment took the following site constraints into consideration:

- Investigations to date have identified PFAS in wells located up and cross hydraulic gradient of the site, associated with other off-site PFAS sources, such as the fuel terminal located south and east of the site. Remedial works to remove PFAS in groundwater from the MFS site are unlikely to be effective unless the works were part of a comprehensive strategy to address all PFAS sources in the area.
- The PFAS in groundwater associated with the site extends beneath several residential properties. A semi-permanent groundwater extraction system (well network and associated manifold) to remove PFAS impacted groundwater from the subsurface would be extremely difficult to implement for the following reasons:
 - Accessible land (streets and footpaths) where an extraction well network could be located would not achieve a sufficient radius of influence to address the plume.
 - Services located within accessible land would impede the installation of a groundwater extraction well network. The presence of services would likely result in significant disruptions to services and local traffic during installation and impose a high-cost burden on the project.
- Based on an assumed plume area of 4.7 ha, an impacted aquifer thickness of 3 m, an effective porosity of 0.3 and an average concentration within the plume of 0.23 µg/L the mass of PFAS within the offsite plume has been calculated to be approximately 10 g. The capital expenditure and resources required to install and run a semi-permanent groundwater extraction and treatment system would be exceptionally high compared to the mass of PFAS that could theoretically be removed from the environment.
- Mobile pump and treatment of groundwater from the available well network would not meet remediation objectives.

Based on the MCA groundwater monitoring utilising the existing monitoring well network combined with community engagement was identified as the most practicable and best option for managing PFAS-impacted groundwater at the site at this point in time. The selection of the option was based on the following rationale:

- PFAS concentrations in groundwater have been observed to be stable to date across the plume area.
- PFAS impacts in groundwater have been assessed to not pose a risk to sensitive receptors.
- Due to the low PFAS concentrations spread over a large area with limited accessibility across the plume, there is currently no technology identified that could successfully remove the PFAS from the subsurface. The contaminant mass, spread over the groundwater plume area, was estimated to constitute less than 10 g of PFAS.
- As remediation of PFAS in groundwater was not considered to be feasible at this point in time, costs were not interrogated, however it is anticipated that they would be significant to remove a very small amount of contaminant mass.

This selected groundwater monitoring approach is aimed at assessing plume stability over time to allow statutory controls to be put in place to limit future use of groundwater. Further monitoring would also ensure that any future PFAS plume migration will be identified and managed.

According to the GAR (Appendix 6) the following information must be included in this section:

- Define remediation approaches
- Discuss impracticability considerations
- Evaluate available and viable remediation options to achieve goals
- Document rationale for selected options
- Document management measures to prevent/reduce additional harm to human health, water or environment
- Determine timeframe for remediation completion
- Review by SA EPA or site contamination auditor
- Determine whether remediation goals, objectives, endpoints have been met

4.4 Further requirements

The ROA recommended the implementation of a SMP to inform the community and all stakeholders of the necessary steps required to manage the PFAS issues at the site. The SMP should have an indefinite timeframe and include a two-year GMMP to manage the groundwater monitoring option.

The ROA was reviewed and endorsed by the auditor.

5. Site Management Measures

The measures detailed within this SMP are applicable to the entirety of the site unless indicated otherwise.

5.1 Site Maintenance

To minimise exposure to PFAS in dust on-site the following control measures are required:

- Regular (e.g. annual) inspections and cleaning of the air conditioning system at the fire station or more often if required.
- Regular cleaning of site surfaces around the fire station, particularly within the kitchen area, over and above normal day to day cleaning.

5.2 Soil Management

To prevent access to on-site soils with residual PFAS and to eliminate potential future dust impacts from PFAS impacted soils, the following control measures are required:

- Maintain the integrity of all geotextile and mulch barriers covering PFAS impacted accessible soils on-site.

Should groundwater monitoring (Section 6) determine increasing PFAS concentrations in groundwater that would indicate that residual soil concentrations are causing ongoing harm to groundwater, remedial options should be considered. These could include stabilisation of PFAS in soil with RemBind® or disposal of PFAS-impacted soil at a local facility if this becomes available in the future.

5.3 Groundwater Management

The groundwater management requirements for the temporal assessment of the PFAS plume stability are detailed in the GMMP in Section 6 below.

6. Groundwater Monitoring and Management Plan (GMMP)

Based on the outcomes of the ROA (GHD, 2021a) summarised in Section 4.3 groundwater monitoring using the existing monitoring well network, combined with community engagement, if required, will be implemented as the most practicable and best option for managing PFAS-impacted groundwater at the site at this point in time. This approach allows to assess plume stability over time and will provide data to inform the implementation of statutory controls to be put in place to limit future use of groundwater. Further monitoring will also ensure that any future PFAS plume migration will be captured and managed.

6.1 Scope of Work – Groundwater Monitoring

Each groundwater monitoring event (GME) will have the following scope:

- Undertake a GME at the 10 monitoring wells listed in Table 6.1. The GME will include gauging of all wells in a single event and sampling using no flow sampling techniques (HDPE Hydrasleeve™ samplers).
- All groundwater samples will be submitted to a NATA-accredited laboratory for analysis of PFAS extended suite ultra-trace LOR.).
- Following each GME, a groundwater monitoring report will be submitted to MFS and the auditor for review and endorsement. The endorsed final GME report will then be submitted to the EPA. The report will include the monitoring results, a comparison to previous results and the adopted assessment criteria and an assessment of the plume stability.

Table 6.1 Groundwater wells selected for further monitoring

Location	Selected Well(s)	Rationale
On-site PFAS source area	MW04	Assess temporal plume stability Assess potential ongoing harm to groundwater in the well with the previously reported highest PFAS concentration
Off-site to the south-west	MW18	Assess impact from off-site PFAS sources up / cross hydraulic gradient Assess temporal plume stability Confirm groundwater flow direction to the north / north-east
Off-site to the north	MW08, MW20	Assess temporal plume stability down hydraulic gradient
Off-site to the north-east	MW09, MW10, MW14, MW15, MW21, MW23	Assess temporal plume stability down hydraulic gradient Identify plume extent down hydraulic gradient

6.2 Methodology

Prior to any site works commencing, a job safety and environment analysis (JSEA) or safe work method statement (SWMS) will be prepared, which will consider the potential specific risks associated with the proposed investigation methods and exposure to chemicals that may be present at the site. All field staff will be required to read, sign and conform to the site specific JSEA.

Details of the groundwater monitoring and sampling methodology are summarised in Table 6.2.

Table 6.2 Groundwater monitoring and sampling methodology

Activity	Details
Well gauging	The monitoring wells' standing water levels (SWL) and bore depths will be gauged in accordance with standard industry practice and field procedures. All on site wells will be gauged prior to sampling with an oil / water interface probe. SWL and bore depths will be recorded digitally or on a Groundwater Gauging Sheet. The measurement will be undertaken from the top of casing (TOC).

Activity	Details
Sampling	<p>Sampling is to be conducted at least seven days after the well development, using a no-purge method via HydraSleeve™ samplers dedicated for each well. The sampler will slowly be lowered into the screened section of the well to minimise disturbance and then drawn up to open the valve. When the sampler is full it will slowly be raised to ensure the valve is closed. All samples are to be collected directly from the sampler sleeve into laboratory supplied containers appropriate for PFAS. The sample containers will be appropriately labelled with a unique job number, sample identification and sampling date.</p> <p>Water quality parameters (pH, dissolved oxygen, electrical conductivity, reduction/oxidation (redox) potential and temperature) will be recorded digitally or on a Sampling Record Sheet using a multi parameter water quality meter. The groundwater will be visually assessed for turbidity and evidence of contamination, such as odour or visible hydrocarbon sheen.</p>
Sampling preservation and transport	Samples will be stored on ice, in an insulated cooler immediately after sampling and will be kept chilled prior to and during delivery to the laboratory. All samples will be transported to the laboratory by Field Staff under Chain of Custody (COC) documentation.
Decontamination	<p>All non-disposable equipment (i.e. oil / water interface probe and water quality meter) will be washed with a PFAS-free and phosphate-free detergent and rinsed with clean water and additionally rinsed with demineralised water before and after each sample is collected.</p> <p>Disposable nitrile gloves are to be worn during sampling and changed between samples to minimise the potential for cross-contamination. Further sample collection, handling and preservation details are summarised in Appendix A.</p>

6.3 Requirement and Frequency of Groundwater Monitoring and Reporting

Groundwater monitoring is required to be undertaken on an annual basis over two years (years 2022 and 2023) at 10 out of 26 selected monitoring wells (refer to Table 6.1) to determine the temporal plume stability, to assess the need for additional remediation, to facilitate the on-going assessment of natural attenuation processes and to ensure that the potential risks to human health and the environment remain low and acceptable.

A groundwater monitoring report detailing the results of the GME must be submitted to the auditor and the SA EPA within approximately two months of completion of the GME.

Groundwater monitoring can cease and the GMMP can be discontinued if all of the following conditions are satisfied:

- Two annual GMEs (2022 and 2023) have been completed;
- The PFAS concentrations in the monitoring wells (on-site and off-site) exhibit a consistent, stable or downward trend over a minimum period of two years;
- There are no significant increases of PFAS in any of the wells selected for monitoring; and
- Cessation of groundwater monitoring has been supported by the site contamination auditor with the auditor recommendation / endorsement that the conditions for cessation have been met provided to EPA for their review and written approval.

It is anticipated that once the plume stability has been confirmed and groundwater monitoring has ceased, the SA EPA may consider implementing a GPA to address regional PFAS impacts on the Le Fevre Peninsula.

6.4 Requirement and Timeframe for Community Engagement

Community engagement will be undertaken if groundwater monitoring identifies an increase in groundwater PFAS concentrations resulting in a change in the level of risk to the identified receptors. If required community engagement will be initiated within one to two months of receiving the laboratory results for the GME if these indicate an increased level of risk. Any community engagement will be undertaken in accordance with the SA EPA (2018) and VSCAP requirements in consultation with the auditor and the SA EPA.

7. Contingency Measures

7.1 Change of Ownership

It is noted that a change of ownership for the site is not planned. However, if a change in property ownership or occupancy occurs at the site, the current owner of the land will be responsible for arranging for the new owner/occupier to receive, and be notified of, the SMP/GMMP and applicable restrictions and obligations.

7.2 Change of Site Use

A change in use of the site will warrant review of this SMP in consultation with the Site Contamination Auditor and the SA EPA.

7.3 Change of Conditions

A documented change in site conditions, particularly any changes to the on-site soils with residual PFAS impacts, will trigger a review of this SMP and consideration of response remedial options in consultation with the Site Contamination Auditor and the SA EPA.

Should a change in conditions cause increased risks posed by the PFAS impacts associated with the site to human health the community is to be informed in a timely manner about these risks and the appropriate control measures to prevent future risk.

7.4 Timeframe for Site Management

While residual PFAS contamination remains on-site, ongoing site management and the implementation of the SMP are required to prevent harm to human health. As such there is no end date for the requirements of this SMP. A change in site use (Section 7.2) or a documented change in site conditions (Section 7.3) may trigger a review of the SMP in consultation with the SA EPA, the Site Contamination Auditor and relevant stakeholders.

Groundwater monitoring may cease as outlined in Section 6.3. However, cessation of groundwater monitoring will not affect the continuing implementation of site management provisions of this SMP.

8. References

- GHD 2019a, Largs North Station and Gallantry PFAS testing Detailed Site Investigation Report for South Australian Metropolitan Fire Service, April 2019
- GHD 2019b, Largs North Station and Gallantry PFAS Testing Site Groundwater Use Survey & Groundwater Investigation, for South Australian Metropolitan Fire Service, 27 May 2019
- GHD 2019c, Largs North Fire Station Draft Preliminary Site Investigation for South Australian Metropolitan Fire Service, 21 November 2019
- GHD 2020a, Largs North Station Groundwater Investigation (October 2019) for South Australian Metropolitan Fire Service, 09 January 2020
- GHD 2020b, Largs North Station and Gallantry PFAS testing, Resident Fruit Testing for South Australian Metropolitan Fire Service, 10 February 2020
- GHD 2020c, Largs North Station Groundwater Investigation (February 2020) for South Australian Metropolitan Fire Service, 21 April 2020
- GHD 2020d, Largs North Station Groundwater PFAS Assessment Sampling and Analysis Quality Plan (SAQP) (June 2020) for South Australian Metropolitan Fire Service, 24 June 2020
- GHD 2020e, Largs North Station and Gallantry PFAS Testing, Detailed Site Investigation (DSI) – Groundwater Assessment (April 2020) for South Australian Metropolitan Fire Service, June 2020
- GHD 2020f, Largs North Station and Gallantry PFAS Testing, Dust Testing – Post Clean Validation Sampling (June 2020) for South Australian Metropolitan Fire Service, 16 July 2020
- GHD 2021a, Largs North Fire Training Station, Remediation Options Assessment (September 2021) for South Australian Metropolitan Fire Service, 24 September 2021
- GHD 2021b, Largs North Fire Station Groundwater Investigation (April 2021) for South Australian Metropolitan Fire Service by GHD Pty Ltd, 14 October 2021
- Gov SA 1993, Environment Protection Act 1993, Version 1.7.2020, Government of South Australia
- Gov SA 2009, Environment Protection Regulations 2009, Version 1.7.2021, Government of South Australia
- HEPA 2020, PFAS National Environmental Management Plan (Version 2.0), Heads of Environment Protection Authorities Australia and New Zealand, January 2020, (PFAS NEMP 2020)
- NEPC 1999, National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM), as amended 2013, National Environment Protection Council
- SA EPA 2018, Site contamination guideline for communication and engagement, Environment Protection Authority, South Australia, November 2018
- SA EPA 2019a, Guidelines for the Assessment and Remediation (GAR) of Site Contamination, Environment Protection Authority, South Australia, revised November 2019
- SA EPA 2019b, Guidelines for the Site Contamination Audit System, Environment Protection Authority, South Australia, revised August 2019

Figures

Figure 1 – Site Location Plan

Figure 2 – Site Layout and Groundwater Monitoring Well Locations Plan

Figure 3 – Soil PFAS Concentrations Plan (2019)

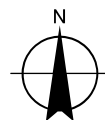
Figure 4 – Groundwater PFAS Concentrations Plan (April 2021)

Figure 5 – Conceptual Site Model



Paper Size ISO A4
0 60 120 180
Meters

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



South Australian Metropolitan Fire Service
Largs North Station
SMP/GMPP

Project No. 33-19080
Revision No. A
Date 11/ 06/ 2022

Site Location Plan

FIGURE 1

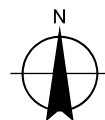


Legend

- Soil Sampling Locations
- Roads
- Site Boundary
- Cadastral

Paper Size ISO A4
0 5 10 15 20
Meters

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

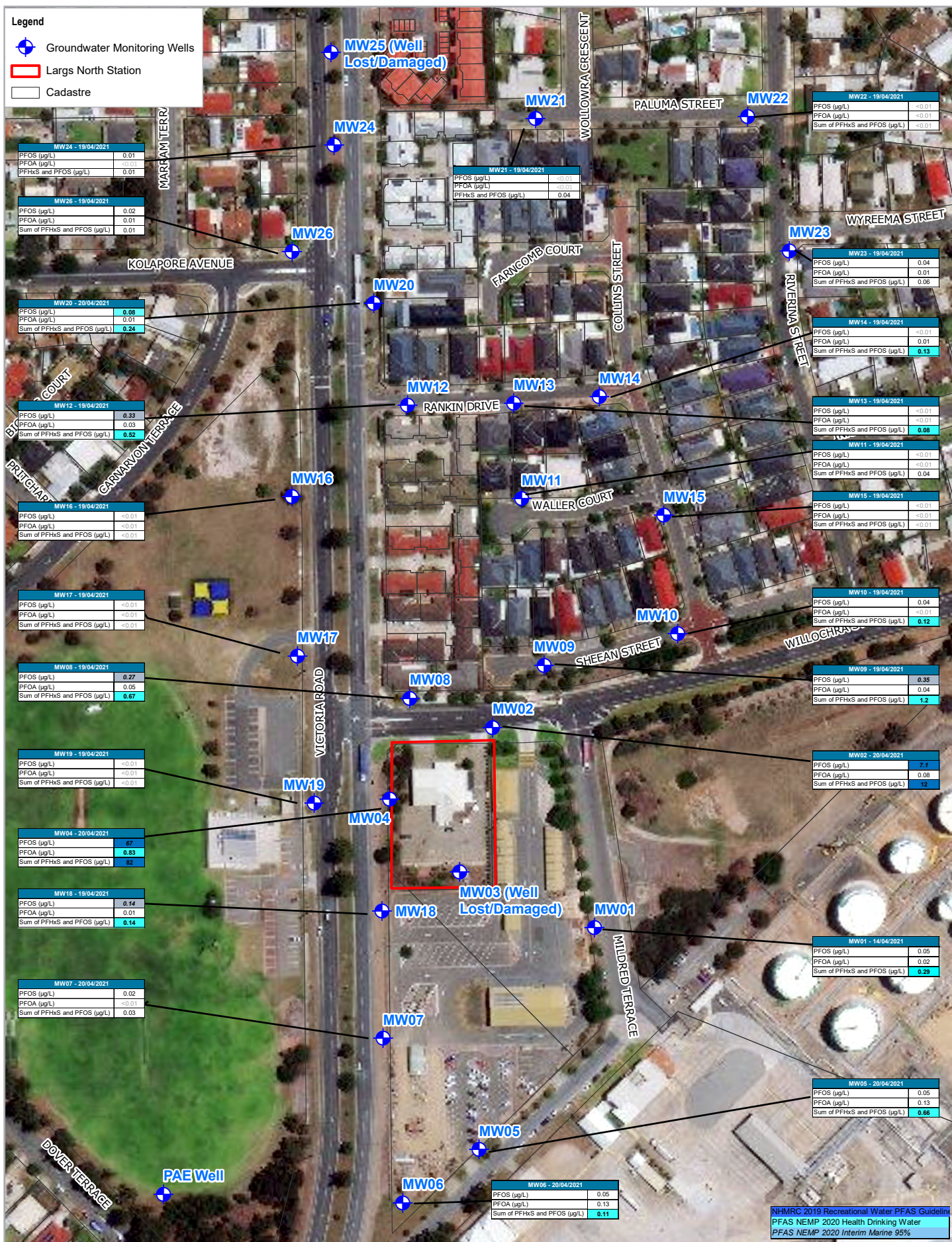


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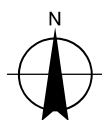
Soil PFAS Concentrations Plan (2019)

Project No. 33-19080
Revision No. A
Date 08/06/2022

FIGURE 3



0 20 40 60 80
Meters
1:2,400 at A4 Approximate
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

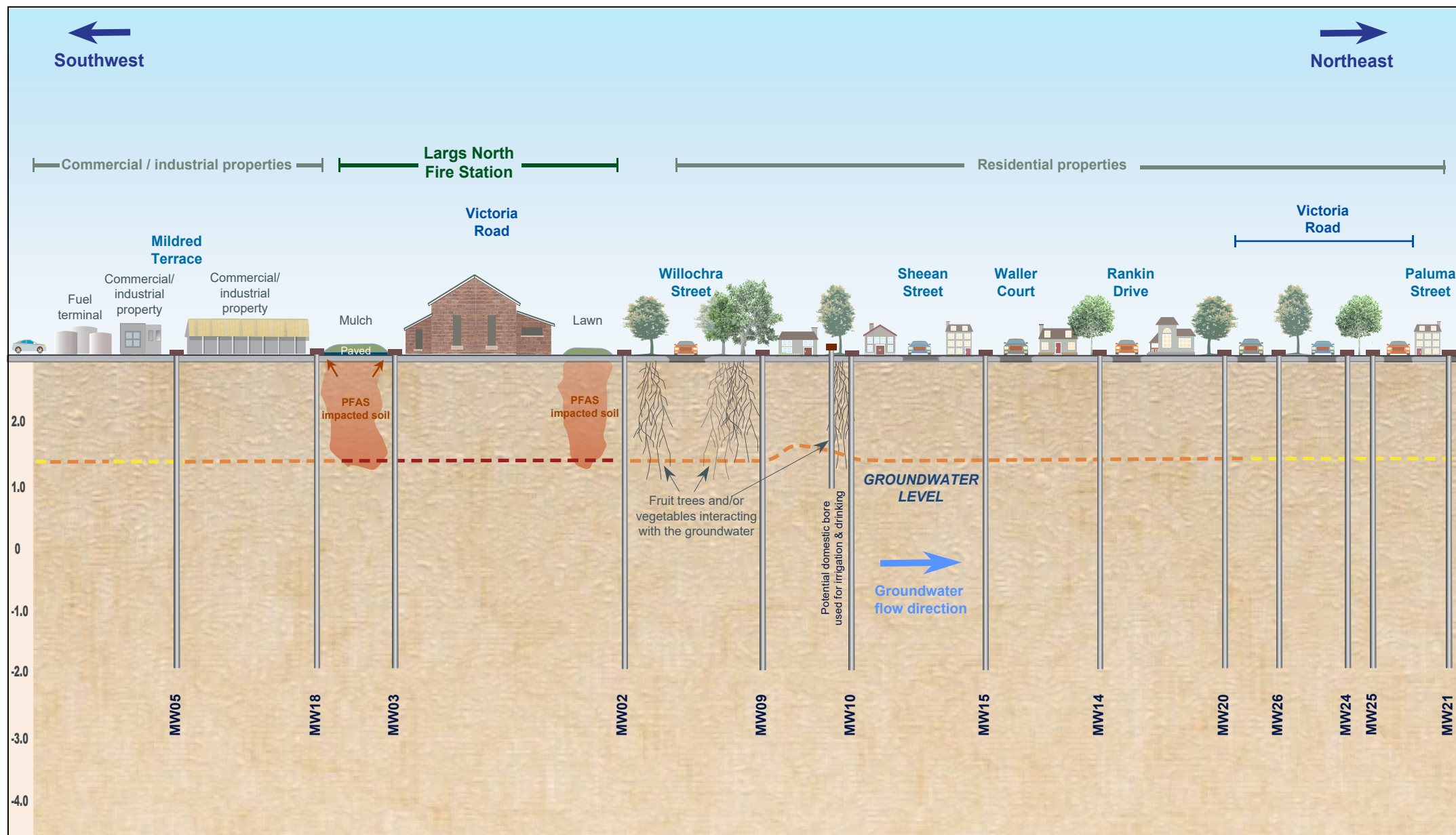


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FIGURE 4



LEGEND

- No criteria exceedances
- Exceeding PFAS NEMP 2020 Health Drinking Water Criteria
- Exceeding PFAS NEMP 2020 Health Recreational Water Criteria



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SMP/GMMP

Conceptual Site Model

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Figure 5

Appendices

Appendix A

**PFAS Sample Collection, Handling and
Preservation (adapted from WA DER,
2017)**

Summary of mitigation practices when sampling for PFAS

Product	Mitigation practices	Alternative approach
Clothing and food		
New clothing	Prohibited for sampling personnel (1)	Wash all field clothing after purchase and before use during field work.
Clothing with stain-resistant, rain resistant, or waterproof coatings/ treated fabric (e.g. GORE-TEX®)		Avoid sampling during rain if possible; polyethylene rain gear (e.g. disposable low-density polyethylene), vinyl, or polyvinyl chloride (PVC) clothing are acceptable.
Tyvek® clothing		Do not use.
Fast food wrappers and containers		Use rigid plastic containers or bags or stainless-steel containers for all food brought to the Investigation Area.
Pre-wrapped foods and snacks (e.g. chocolate bars, energy bars, granola bars, potato chips etc.)		Re-package food brought to the Investigation Area into rigid plastic containers or bags or stainless-steel containers.
Sampling equipment and containers		
Teflon®-lined lids on containers (e.g. sample containers, rinsate water storage containers)	Prohibited at site (2)	Use polypropylene lids (3) for sample containers and polypropylene or HDPE containers for rinsate as supplied by the laboratory for PFAS samples.
Glass sample containers with lined lids	Do not use	Use polypropylene or HDPE sample containers (3) supplied by the laboratory for PFAS samples (PFAS adsorb strongly to glass).
Other products		
Aluminium foil	Prohibited at site (2)	Use thin HDPE sheeting (commonly used as drop cloths for painting or home improvement) as an acceptable alternative if required.
Self-sticking notes and similar office products (e.g. 3M Post-it notes)	Prohibited at site (2)	Avoid using these products at the site.
Waterproof paper, notebooks, and labels	Prohibited at site (2)	Use standard paper and paper labels.
Detergents and decontamination solutions (e.g. Decon 90® Decontamination Solution)	Prohibited for all equipment	Use PFAS-free and phosphate-free detergent Liquinox ® for decontamination followed by rinsing with water.
Reusable chemical or gel ice packs (e.g. Blue Ice®)	Prohibited for sample storage and transport	Use ice contained in plastic (polyethylene) bags (double bagged) or frozen HDPE water bottles as instructed by the laboratory.

Notes:

(1) Sampling personnel includes all personnel who are:

directly involved in the collection, handling, and/or processing of samples prior to the samples leaving the Investigation Area; or handle any part of equipment that directly comes into contact with the groundwater; or within 2–3 m of the sampling location during sampling.

(2) Entire sample collection and processing area, including vehicles used by sampling personnel.

(3) United States (US) Environmental Protection Agency (EPA) and American Society for Testing and Materials (ASTM) method for the analysis of PFAS in solid and liquids specify polypropylene or HDPE with polypropylene lids.



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