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Oceana Gold (New Zealand) Ltd
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Attention: [redacted]

21 August 2026 WWLA1659

**Macraes Operation – Preliminary Assessment of PFAS Risk**

***There is potential for per- and polyfluoroalkyl substances (PFAS) contamination to have arisen at the Macraes Operation because of historic lawful use of PFAS containing Aqueous Film-Forming Foams (AFFF) for fire protection in the mine operations. It is currently hypothesised that much of the mass of PFAS contamination derived from the mine operations is likely to be entrained in process water and tailings. An overall low risk to environmental receptors is therefore inferred. However, this hypothesis needs to be quantified by sampling. The works and compliance monitoring proposed as part of the MP4 Project provide an opportunity to quantify, and if necessary, mitigate effects that may have arisen from these historic activities.***

## 1. Introduction

Williamson Water & Land Advisory (WWLA) is pleased to present this preliminary assessment of risk associated with the historic use of per- and polyfluoroalkyl substances (PFAS) at the Macraes Operation for Oceana Gold (New Zealand) Ltd (OGNZL).

## 2. Background

OGNZL currently undertakes open pit and underground gold mining operations at the Macraes Operation located at Golden Point Road, Macraes, East Otago. As part of their ongoing operations, OGNZL continually review the remaining life of the Macraes Operation in light of updated knowledge of the gold resource and the economics of mining.

Reflecting recent exploration success and optimisation work, together with higher gold prices, the Macraes Phase Four Project ("MP4" or "the Project") seeks to extend the life of mining at the Macraes Operation through to 2036. An overview of the Project, which has the potential to add more than 890,000 ounces of gold production, is provided in **Figure 1**. It is identified as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 ("FTAA") as a project of national significance.

To support the development of the substantive application for the Project, OGNZL has engaged WWLA to provide an assessment of ground contamination in the context of the Project and, to the extent required, identify any necessary management and operation measures to address any such effects. WWLA has prepared the following reports for OGNZL, which should be read alongside this assessment:

- Macraes Operation, Preliminary Site Investigation (Ground Contamination), dated 18 August 2026;
- Macraes Operation, Detailed Site Investigation (Ground Contamination): Open Pit Mining Workshop, dated 18 August 2026; and
- Macraes Operation, MP4 Project, Interim Site Management Plan (Ground Contamination), dated 18 August 2026.

These assessments identified that there is potential for PFAS contamination to have arisen because of historic use of use of Aqueous Film-Forming Foams (AFFF) for firefighting in the mine

operations. In accordance with changes in regulations, AFFF used at the mine is now fluorine free and does not contain PFAS. But PFAS containing AFFF use has historically occurred.

The objective of this assessment is to provide:

- A summary of the current knowledge of AFFF use in Macraes operations.
- Determine the primary potential sources of PFAS associated with the known AFFF uses.
- Provide a preliminary evaluation of the potential risk presented by PFAS.
- Set out a framework of investigations to support quantification of the PFAS risk.

### 2.1 Scope of work

The scope of work has comprised:

- Review of information provided by OGNZL to understand AFFF use in Macraes operations.
- Review of the supporting information to inform the potential effects of, and options for monitoring, PFAS discharges, including:
  - Macraes Phase 4 FTA, Surface and Groundwater Assessment. Report prepared for OGNZL by GHD Limited, dated August 2026.
  - ORC Quarterly Monitoring Report, QMR #112 – December 2025 to February 2026[1]. Prepared by OGNZL.
  - Macraes MP4 Project, Assessment of Aquatic Environmental Effects. Report prepared for OGNZL by Viridis Limited, dated August 2026.
- Preparation of this letter report which provides a preliminary assessment of PFAS risk.

### 2.2 Legislative compliance

WWLA has prepared this report in consideration of the requirements of published industry best practice guidance, including:

- Ministry for the Environment ("MfE") Contaminated Land Management Guideline No. 1: Reporting on Contaminated Sites in New Zealand (Revised 2021), (CLMG1).
- PFAS National Environmental Management Plan Version 3.1, Heads of EPA Australia and New Zealand 2025 (PFAS NEMP).

This report has been prepared, reviewed, and certified by a SQEP as described in the NESCS and NESCS Users' Guide[2]. CVs confirming the SQEP status of contaminated land specialists are available on request.

### 2.3 Report structure

This report has been structured following the Source-Pathway-Receptor (SPR) model commonly used as a risk assessment framework. The SPR elements are introduced in **Sections 3** to **5**, and a preliminary Conceptual Site Model (SCM) which summarises the SPR relationships is provided in **Section 6**.

[1] Note the report is incorrectly titled "…December 2025 to February 2025…".
[2] Ministry for the Environment, April 2012. *NESCS Users' Guide: National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health*.

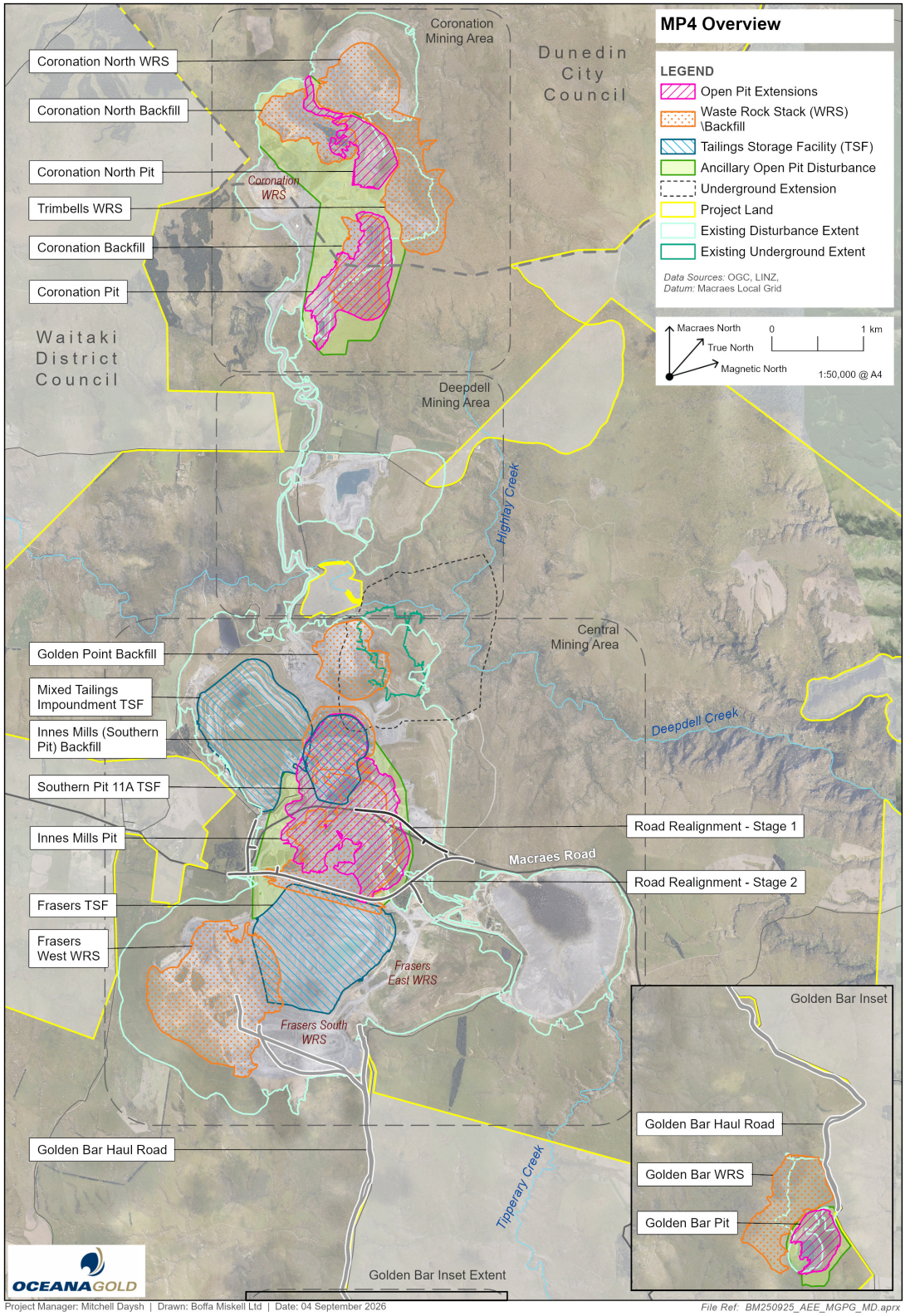


**Figure 1. MP4 Project overview plan (source: OGNZL)**

# 3. Sources

## 3.1 About PFAS

PFAS are a group of thousands of synthetic chemicals that have been manufactured since the 1940s. They are used to make products resistant to heat, stains, grease, and water. PFAS have been used in a wide variety of consumer products, including food packaging, cookware, clothing, carpets, furniture, and cleaning products. PFAS have applications in many industries including medical, automotive, construction and electronics.

PFAS compounds are persistent in the environment. Because of this, and their wide usage, they are found in the environment worldwide, including in humans and animals. People are exposed to small amounts of some PFAS in everyday life, and most people have small amounts of these substances in their systems.

In addition to the widespread use of PFAS in consumer products, the historic use of these compounds in AFFF used for fighting flammable liquid fires has been identified as a signficant contributor of PFAS to the environment. Due to their ability to rapidly suppress flammable liquid fires PFAS containing AFFF became standard issue for over 50 years across specialised sectors handling high volumes of flammable hydrocarbons.

## 3.2 Current knowledge of AFFF use in the Macraes operations

Discussions with OGNZL personnel have identified that AFFF storage and use in the mining operations comprises:

- Fire extinguishers installed at mining facilities (principally workshop areas);
- Fire extinguishers and fire suppression systems installed on all mine heavy vehicles;
- Firefighting supplies held by the mine emergency response team (ERT);
- Storage of foam at the mine workshop facilities for refilling heavy vehicle fire suppression systems following activation or servicing.

Discharges of AFFF has historically occurred:

- During servicing of fire suppression systems installed on the mine heavy vehicle fleet;
- As a result of activation of the systems during mining operations; and
- Occasional training activities using AFFF containing fire extinguishers and firefighting equipment.

Further details of current and historic AFFF use are provided in the following subsections.

### 3.2.1 AFFF types and storage

We understand that the mine hazardous substance inventory historically showed that 200 litres of Petroseal C6 6% and 210 litres of Alcoseal C6 3-6% foam concentrates were stored at the open pit (main) workshop. Discussions with OGNZL personnel also indicate similar quantities were stored at the former Frasers Underground (FRUG), but that a MusterFire product was in use in those underground operations. Owing to the later commencement of mining only fluorine free (non-PFAS) foams have been used at the Golden Point Underground (GPUG). ERT are reported to have previously used Angus Tridol. All PFAS containing products were substituted for the fluorine free foams, indicated in **Table 1** (overpage), as PFAS was phased out in accordance with changes to New Zealand legislation.

**Table 1. Current AFFF product types and locations**

| Location | AFFF product | Quantity |
|---|---|---|
| Main workshop | Sandvik Eclipse Sustain | ~200 litres comprising:<br>• 8 x Eclipse Fire Suppression service packs at 6 litres each held by the mine workshop, totally 48 litres<br>• 33 kits of various sizes held by Sandvik in its storage container, totalling ~140 litres. |
| Open pit operations | | ~ 360 litres across the heavy vehicle fleet |
| Underground storage* | Silvara 1 | ~40 litres in storage |
| Underground operations* | | ~30 litres distributed across the light and heavy vehicle fleets |
| ERT | Solberg Versagard AS-100 | 60 litres |
| * owing to their smaller size and fuel capacity underground vehicles carry smaller quantities of AFFF | | |

While a full record of previous PFAS containing foam storage has not yet been established the current quantities are considered to provide a good indication of historic activities, noting:

- The mine heavy vehicle fleet has grown over time so the current operational quantities are conservative; and
- The AFFF quantities set out in **Table 1** exclude AFFF fire extinguishers as these have always been serviced offsite, i.e. have low potential to result in discharges unless activated.

It should also be noted that while PFAS containing AFFF has been standard practice for over 50 years in some industries (e.g. aviation), AFFF fire suppression systems only began appearing on heavy machinery in New Zealand during the late 1990s and early 2000s, aligning with the broader Australasian adoption of formal mobile plant safety practices which had commenced earlier in the 1990s[3]. Prior to this time heavy equipment relied primarily on dry powder or manual extinguishers with foam liquid systems integrated progressively as hydraulic excavator and large loader engine bay fires prompted better risk mitigation in high-risk sectors such as mining. The establishment of *AS 5062: Fire Protection for Mobile and Transportable Equipment* in 2006 provided the first definitive benchmark utilised across New Zealand and Australia for engineering, installing, and servicing these heavy vehicle systems. So, in comparison to some industries PFAS containing AFFF have only been in use for a relatively short period of time (15 to 20 years) in the mining sector.

### 3.2.2 AFFF system servicing and testing activities

For the open pit operations servicing of fire suppression systems occurs on a 2-yearly basis. For most of the mine heavy vehicle fleet servicing occurs at the Main Workshop facilities. The fire suppression systems are activated on the workshop apron (**Photograph 1**) where perimeter drains ultimately direct the discharge to a gully / swale (**Photograph 2**) that flows into the Mixed Tailing Impoundment (MTI).

[3] https://www.resources.nsw.gov.au/sites/default/files/documents/mdg-15-guideline-for-mobile-and-transportable-plant-for-use-at-mines-other-than-underground-coal-mines-2020-version.pdf

**Photograph 1. Eastern side of Main Workshop, wash water draining to slot drain**

**Photograph 2. View east from western gully (looking up to Workshop platform)**

We understand that the fire suppression systems have always been serviced in a similar manner. Therefore, there is potential for PFAS containing discharges generated during servicing of the foam suppression systems to have been released to ground. However, these discharges are most likely to be captured by the surface and subsoil drainage systems associated with the MTI. Discharges from the MTI drainage systems are directed back into the Mine Water Management System (MWMS). While these systems are expected to have reduced the potential for PFAS to have discharged beyond the mine operations the impact to groundwater and the wider receiving environment cannot be excluded at this time.

Excavators are typically subject to mobile servicing, due to the logistical constraints of moving this equipment. These activities may have contributed PFAS to ground more widely across the mine operations, albeit they are infrequent (2-yearly), of small scale and discharges are typically directed to the MWMS. Nevertheless, the impact to groundwater and the wider receiving environment cannot be excluded at this time.

In contrast to the open pit operations, all underground equipment is tested on a 3 monthly basis. This comprises a brief activation of the system to check foam generation. Foam is discharged to ground and drains into the MWMS. We understand that a similar testing regime was also historically implemented at the FRUG. There is potential for PFAS discharged during this testing to have been distributed more widely via the MWMS.

### 3.2.3 AFFF system activations

OGNZL's records of fire related incidents show there have been 72 instances of fire suppression system activations across the mine operations since 2015. These incidents have typically occurred in active operational areas, as a result most have now been mined out. PFAS derived from these activities has therefore either been transferred to the TSFs through processing of the mined materials or to waste rock stacks (WRS) or backfill stockpiles.

Discharges from the TSFs are reused as process water for the Processing Plant, resulting in a closed system and reducing the potential for PFAS to have discharged beyond the mine operations. Nevertheless, the presence and fate of PFAS in the TSF discharges will need to be assessed.

As described in relation to remote servicing of excavators (above), rock affected by discharges from AFFF system activations that has subsequently been transferred to WRS or backfill stockpiles represents a more diffuse source of PFAS, albeit these incidents are infrequent and of small scale relative to the size of the mining operations (i.e. there is potential for significant attenuation). Nevertheless, impact to groundwater and the wider receiving environment from such these activities cannot be excluded at this time.

### 3.2.4 Fire training

The mine does not include designated fire training areas or bulk foam application equipment typical of airports or fire service training facilities. Training activities using AFFF only occur infrequently and typically in operational areas are subsequently mined out. The training activities are therefore considered to present a potential diffuse source of PFAS, in a similar manner to remote servicing of excavators and incidents / activations. The potential effect of this activity would be addressed by assessing the impact to groundwater and the wider receiving environment on a mine wide basis.

### 3.3 Primary PFAS sources

The information available to date indicates that the primary sources of potential PFAS contamination in the Macraes Operations can be summarised as:

1) Mine workshop: where most of the servicing of the fire suppression systems fitted to the mine heavy vehicle fleet occurs. There is potential for impact around the servicing areas and downstream infrastructure including stormwater systems and swales. The potential for contamination to have reached groundwater underlying the workshop area, providing a secondary source of contamination, cannot be excluded at this time but the working hypothesis is that most discharges are intercepted by the MWMS. In the case of the Main Workshop these discharges are principally directed to the MTI.
2) The MTI: which is inferred to be both a secondary source of PFAS, due to intercepting PFAS discharges from the Main Workshop and potentially in processed ore, and a potential pathway for PFAS to enter process water used in the Processing Plant (below).
3) Process water: which derives from the MTI has the potential to be impacted by PFAS. Other TSFs, that may be impacted by PFAS contamination derived from processing ore affected by more diffuse sources of PFAS (suppression system activations, remote servicing and training), also have potential to contribute PFAS to the process water. Byproducts of the gold extraction process, such as tailings and spent granular activated carbon (GAC), also have the potential to entrain PFAS. However, we understand that this system is principally a closed loop.
4) Diffuse sources: it is possible that low levels of residual PFAS contamination are present more widely, primarily in surface water and groundwater, because of incidents, training and remote servicing in both the open pit and underground workings. However, it is possible that the infrequent nature and small scale of these activities, combined with reworking of materials during mining operations, has diluted the effects below measurable levels.

Quantification of these sources has not been undertaken at this stage. Proposed investigations are described further in **Section 7**. It should be noted that these sources of PFAS have arisen through historic lawful use of substances which have later been identified as presenting potential risks to human health and the environment. OGNZL has replaced these products as required by changes in legislation. The works and compliance monitoring proposed as part of the MP4 Project provide an opportunity to quantify, and if necessary, mitigate effects that may have arisen from these historic activities.

## 4. Exposure pathways

An exposure pathway is the physical course or media by which a contaminant is transported from its source to a human or ecological receptor. The setting of Macraes Operation is described in detail in the reports set out in **Section 2**, but the key elements as they relate to exposure pathways are:

- The topography of the area surrounding the Macraes Operation comprises an erosional surface, or peneplain, formed on Rakaia terrane Otago Schist, which is expressed as gently rolling hills, between approximately 500 and 550 m RL, bisected by deeply incised streams.

- Much of the water generated by dewatering and tailings storage facilities (TSFs) is utilised in the MWMS as process water and therefore becomes a largely closed system. It is hypothesised that most of the discharges from the primary PFAS sources are captured as process water. Therefore, much of the mass of PFAS contamination in the mine operations is thought to be entrained in process water and associated byproducts. However, stormwater discharges from the mine do occur to the surrounding streams. These discharges provide a pathway by which PFAS contamination could be released to the surrounding environment, particularly where the potential for relatively undiluted seepage discharge to surface water is considered high i.e. Frasers South WRS to Murphys Creek.
- Similarly, groundwater discharges from the mine to the surrounding streams. While modelling results (GHD, 2026) indicate that dewatering for the proposed pit and underground workings extensions will reduce groundwater discharge to some local streams and creeks, this pathway is currently complete and is expected to continue to remain so.
- Dust is also a potential vector by which PFAS could be discharged from the mine operations. But given the localised source of potential high concentrations of PFAS at the Main Workshop this pathway is not expected be complete. Especially taking into consideration the dust management measures implemented at the mine.

In summary, potentially complete pathways are currently expected to be limited to diffuse sources in WRS or backfill stockpiles discharging to surface water and/or via groundwater discharging to surface water, similarly there is potential for discharges to surface water from underground operations. However, as noted previously, quantitative assessment (sampling) is required to validate the working hypothesis relating to these pathways.

# 5. Receptors

As described above, receptors can be either human or ecological. Further detail is provided in the following subsections, but in summary, the working hypothesis is that relevant receptors are expected to be limited to environmental receptors in surface water systems around the Macraes Operations. Human receptors are not expected to be adversely affected.

It is currently hypothesised that much of the mass of PFAS contamination derived from the mine operations is entrained in process water and associated byproducts. An overall low risk to environmental receptors is therefore inferred. However, this hypothesis needs to be quantified by sampling.

## 5.1 Human receptors

For the following reasons human receptors are not expected to be adversely affected by PFAS contamination derived from Macraes Operations:

- Modelling using sulphate as a conservative tracer, under current and proposed mining activities, indicates that existing users of groundwater in the vicinity of the mine are not expected to be intersected by the predicted plume extent. Adverse effects on groundwater users are therefore considered unlikely. We consider that this interpretation can be extended to PFAS contamination.
- While much of the mass of PFAS contamination in the mine operations is thought to be entrained in process water and associated byproducts, there is potential for PFAS to be present in surface water discharges from the mine operations (both directly and via groundwater). However, while several consented surface water takes are present downstream of the Macraes Operation, the nearest are greater than 8 km downstream. Given the size of the catchments and anticipated diffuse nature of contamination users of these takes are unlikely to be subjected to unacceptable effects relative to existing ambient exposures to PFAS compounds. Also, with one exception, surface water use is for stock watering and irrigation purposes which significantly reduces the potential for unacceptable exposures to occur to human receptors.

- Our experience with airport fire training facilities where significant volumes of AFFF have been used, is that it is rare for PFAS to be present at concentrations that exceeds the available standards for the protection of the health of site workers under a commercial / industrial land use scenario. As AFFF use in Macraes Operations has not approached these levels it is highly unlikely that PFAS contamination that presents an unacceptable risk to the health of site workers will be present. In the unlikely event that high concentration are present, these are expected to be localised and the risk reduced accordingly. In addition, OGNZL has robust health and safety procedures to minimise exposure to contaminants such as arsenic. If these are carried out, they will also protect workers from risks associated with PFAS contamination.

### 5.2 Environmental receptors

As noted previously, while much of the mass of PFAS contamination in the mine operations is currently thought to be entrained in process water and associated byproducts, there is potential for PFAS to be present in surface water discharges from the mine operations (both directly and via groundwater). The potential risk to environmental receptors needs to be quantified by sampling.

However, we note that environmental effects (if any) have arisen from historic lawful use of PFAS containing AFFF. If present the effects will have been occurring for some time. Implementation of the MP4 Project is very unlikely to adversely change the effects, rather it provides an opportunity to quantify, and if necessary, mitigate effects as part of the proposed works and associated compliance monitoring.

## 6. Preliminary Conceptual Site Model

A CSM indicates known and potential sources of contamination, routes of exposure ("pathways"), and receptors that may be affected by contaminants moving along those pathways. Receptors may be human or environmental. Investigation and potentially remediation are required where contamination is present at elevated concentrations and there is potential for complete pathways between sources of contamination and receptors. A preliminary CSM for potential PFAS contamination at Macraes Operations is provided in **Table 2**.

**Table 2. Preliminary CSM for PFAS contamination**

| Source | Potential receptors | Exposure pathways | Assessment |
|---|---|---|---|
| Potentially high concentrations of PFAS present locally at and downstream of the Main Workshop. Diffuse contamination present more widely across the mine operations from | Neighbouring site users or occupants | Abstraction and ingestion of surface or groundwater, inhalation of dust. | **Incomplete pathway:** Modelling predicts that adverse effects on groundwater users are unlikely, and contamination is not expected to be present in sufficient concentrations in either surface water or dust to present an unacceptable risk to these receptors. |
| | Site workers | Dermal contact, ingestion of soil or inhalation of dust. | **Incomplete pathway:** It is unlikely that contamination is present in near surface soils at concentrations that present an unacceptable risk to the health of site workers. In addition, OGNZL has robust health and safety procedures to minimise exposure to contaminants such as arsenic. If these are carried out, they will also protect workers from risks associated with PFAS contamination. |

| Source | Potential receptors | Exposure pathways | Assessment |
|---|---|---|---|
| incidents, training and remote servicing | Ecological receptors at the nearest surface water bodies | Leaching to groundwater or surface water runoff from the site | **Potentially complete pathway:** While much of the mass of PFAS contamination in the mine operations is currently thought to be entrained in process water and associated byproducts, there is potential for PFAS to be present in surface water discharges from the mine operations (both directly and via groundwater). The potential risk to environmental receptors needs to be quantified by sampling |
| | Ecological receptors at sites receiving PFAS impacted materials. | Leaching to groundwater or surface water runoff at the receiving site of disposed material. | **Potentially complete pathway:** If PFAS contaminated materials (soils, tailings, construction materials, water, GAC etc.) are proposed to be removed from the mine they must be disposed of to an appropriately consented receiving facility. It should be noted that few facilities are willing to accept PFAS contaminated materials and the costs are high. |

## 7. Data gaps and recommended investigations

This assessment has identified the following data gaps that should be addressed as the MP4 Project progresses:

1) Further information on historic use of AFFF, and other potentially PFAS containing substances, in the mining operations should be collated to inform PFAS risk and associated investigations (below).
2) Quantification of the presence of PFAS in soils and water are recommended, as follows:
    a) Targeted soil sampling should be conducted around current and former workshop facilities, in areas affected by runoff from these, and any other areas where PFAS containing AFFF use and/or discharge may have occurred regularly or at high volumes / concentrations.
    b) In discharges from TSFs, particularly the MTI.
    c) In process water, including an assessment of the transfer of PFAS to byproducts such as tailings and spent activated carbon.
    d) In surface water in the streams and creeks surrounding Macraes Operations. OGNZL's existing compliance monitoring points (or a subset of them) can be utilised for this purpose.
    e) In groundwater to provide both coverage across the wider mine operations and to investigate the primary zones of groundwater discharge from it. OGNZL's existing compliance monitoring wells (or a subset of them) can be utilised for this purpose.
3) The findings of the monitoring set out in point 2) should be:
    a) Integrated into the preliminary CSM set out in **Section 6** of this assessment, alongside the physical CSMs developed for the mine surface water and groundwater models (specifically Section 4.1 and Figures 4.2 to 4.4 of GHD modelling reports, as introduced in **Section 2.1**).
    b) If potentially unacceptable effects are identified:
        - PFAS could be included in the existing contaminant transport models developed for the mine; and
        - If necessary, mitigation measures should be included in the MP4 Project, including evaluation alongside the existing water quality and flow mitigation measures contemplated in relation to the project (as set out in GHD, 2026).

4) Consideration should be given to whether further measures are required to capture and/or treat discharges during future servicing of fire suppression systems. While fluorine free foams (F3 foams) are now in use residues to PFAS can remain and the potential effects of

## 8. Implications for MP4 Project

### 8.1 Consenting

In our opinion the existing consenting framework for the MP4 Project provides sufficient control mechanisms to allow the potential effects of legacy PFAS contamination to be appropriately quantified and managed, and if necessary mitigated, as the MP4 Project progresses. This can be achieved by inclusion of appropriate conditions of consent requiring the assessment of PFAS contamination and, if necessary subsequent management or remediation, subject to approval by Otago Regional Council.

It is acknowledged that additional consents may be required if specific management or remediation of PFAS discharges are required. But these can be obtained when required.

### 8.2 Operational procedures

As PFAS contamination (if any) has already occurred and these products are no longer used in Macraes Operations there is no need for immediate change to the mine operational procedures. Rather, the investigations recommended in **Section 7** should be advanced as soon as practical.

The only material constraint to mine operations should be limiting excavation or ground disturbance around the Main Workshop, and in areas affected by runoff from it, and any other areas where PFAS containing AFFF use and/or discharge may have occurred regularly or at high volumes / concentrations, until these areas have been appropriately investigated.

## 9. Closure

Please contact the undersigned if you have any questions in relation to this assessment.

Yours sincerely,

**Shane Moore**
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