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FINAL REPORT

NACOE O31: Regulated Waste Reduction Through Paint Wash Water and Raised Pavement Markers (RPMs) – Year 1 (2023–24)

ARRB Project No.: 000890

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Summary

The Australian Road Research Board (ARRB) was engaged by the Queensland Department of Transport and Main Roads (TMR) as part of the National Asset Centre of Excellence research program to assess the potential for regulated waste reduction of waste raised pavement markers (RPMs) and linemarking paint wash water on behalf of the RoadTek branch.

The primary purpose of this project was to assess the waste RPMs and linemarking paint wash water to determine if the waste category can be changed from regulated waste to non-regulated waste. If the waste categories can be changed, it will allow RoadTek to reduce disposal costs and may enable these materials to be recycled in the future.

The project also included a review of options which could be used to separate the paint solids from the liquid components in the washings from linemarking equipment and determine if there is a difference between linemarking paint and architectural paint (which is not classified as regulated waste).

The following key scope items required by the project have been addressed:

- Stage 1: Technical support was provided to optimise the chemical treatment systems used to separate water from paint at RoadTek’s Toowoomba depot. Note: the paint wash water treatment technical support component of the project has not been included in this final report in accordance with the agreed project scope of work.
- Stage 2: A preliminary technical review was conducted by an external environmental consultant (EnRiskS) which relates to the classification of RPMs and the linemarking paint wash water.
- Stage 3: Laboratory analysis of samples of RPMs and linemarking paint wash water based on the advice obtained in Stage 2 was undertaken.
- Stage 4: EnRiskS conducted a review of the test data obtained in Stage 3 to determine whether RPMs and linemarking paint wash water have the potential to be of concern in relation to human health and the environment, and whether the data supports a different waste classification for disposal.
- Stage 5: A technical report (this report), has been prepared by ARRB detailing a summary of the background, project process and main conclusions of the work conducted by the external consultant.

In carrying out a legislation review and consulting with the suitably qualified person, it was recognised that the current Queensland waste framework includes a waste classification process via a default or sampling and analysis process. An end of waste framework is also in place to enable the beneficial reuse of materials for a specific purpose or industry. The review also highlighted the legislated requirements TMR has to meet its general environmental duty and has a primary duty of care to look after the health and safety of all persons who may be affected by TMR’s activities.

The preliminary technical review identified the status of the waste RPMs and waste linemarking paint wash water, including the current waste classification and the potential contaminants of concern present within

the materials. The technical review provided a summary of potential treatment methods for the paint wash water, including:

- nanotechnology
- membrane separation
- coagulants and flocculants.

Further, a comparison of the status of industrial and architectural or decorative paints was undertaken as industrial waste is considered regulated, whereas architectural or decorative paints are considered non-regulated. EnRiskS identified the following possible reasons for this dichotomy:

- Industrial paints may be produced and/or used in larger volumes.
- Industrial paints may contain different chemicals to architectural or decorative paints (e.g. metals or higher concentrations of solvents) as they are developed for specialist applications.
- Industrial paints may be used with other additives.

Sampling and laboratory analysis of the waste materials was conducted to confirm the extent of the potential contaminants of concern present, and to provide a basis for comparison against current accepted waste classification standards and guidelines. The outcomes of the sampling and laboratory analysis indicated:

- The linemarking paint wash water will remain classified as regulated as per the initial assessment based on the presence of detected per- and poly-fluoroalkyl substances (PFAS), copper, zinc, electrical conductivity (Ec) and biological oxygen demand (BOD).
- The waste RPMs will remain classified as regulated; however, the classification can be lowered from Category 1 to the less hazardous Category 2. The potential contaminants of concern detected within the waste RPMs include pH and total petroleum hydrocarbons (TPH).

A risk assessment for the beneficial reuse of the waste RPMs was undertaken for the assessment of:

- Application 1 – partial aggregate replacement in asphalt
- Application 2 – use in materials underlying asphalt (encapsulating the waste RPM, where fresh asphalt is laid over older asphalt with RPMs affixed).

An additional end of waste assessment for the use of waste RPMs in unbound applications was also undertaken. All human health and ecological risk assessments determined the material is suitable for reuse in the proposed applications. Due to the presence of volatile organic compounds (VOCs) and total recoverable hydrocarbons (TRH) exceeding nominated guidelines, the material is not considered suitable for use underneath buildings without further assessment.

Contents

Tables

Figures

1. Introduction

1.1 Background

The Queensland Department of Transport and Main Roads (TMR) RoadTek branch delivers pavement marking projects across the state that generate regulated waste from raised pavement markers (RPMs) and water-based paints. TMR is committed to reducing waste disposal to landfill and increasing recycling rates in support of Queensland Government commitments.

RoadTek currently removes approximately 400,000 to 800,000 RPMs each year, resulting in approximately 40 to 80 tonnes of regulated waste. RoadTek also disposes of between 20,000 and 50,000 L of liquid regulated waste each year which is produced as a result of the maintenance and cleaning of water-based paint linemarking equipment (linemarking paint wash water).

The waste generated from the waste RPMs and linemarking paint wash water are currently disposed of as regulated waste at appropriately licensed facilities. These materials have each been assigned a default regulated waste categorisation as no sampling and testing has historically been completed.

1.2 Project Purpose and Objectives

The primary purpose of this project was to assess the waste RPMs and linemarking paint wash water to determine if the waste category can be changed from regulated waste to non-regulated waste. If the waste categories can be changed, it will allow RoadTek to reduce disposal costs and may enable these materials to be recycled in the future.

The project also included a review of options which could be used to separate the paint solids from the liquid components in the washing of linemarking equipment and to determine if there is a difference between linemarking paint and architectural paint (which is not classified as regulated waste). This review was supplemented by technical support provided to optimise the chemical treatment system used at the Toowoomba depot, currently used to separate water from paint solids.

1.3 Scope of Work

The scope of work for this project encompassed the following 5 key stages:

- Stage 1: Provision of technical support to optimise the chemical treatment systems used to separate water from paint at RoadTek's Toowoomba depot
  - the paint wash water treatment technical support component of this project has not been included in this final report in accordance with the agreed project scope of work.
- Stage 2: Conduct of a preliminary technical review by an external environmental consultant (EnRiskS) which relates to the classification of RPMs and the linemarking paint wash water. Activities in the preparation of the report to include:
  - reviewing the nature of the waste RPMs, identifying the key chemicals that are relevant to these materials and identifying the sampling and analysis required to be undertaken to enable reclassification of RPMs to be considered

  - reviewing the nature of the linemarking paint wash water, identifying the key chemicals that are relevant to this liquid waste and identifying the sampling and analysis required to be undertaken to enable reclassification to be considered

  - reviewing the available options for the pre-treatment of the linemarking paint wash water, including a review of available methods and treatment chemicals that would assist in separating solids from the wastewater

  - carrying out an assessment of the differences between linemarking paint and architectural paint and recommendations for tests that could be performed to compare the 2 materials (if appropriate).

- Stage 3: Laboratory analysis of samples of RPMs and linemarking paint wash water based on the advice obtained in Stage 2
  - RoadTek coordinated the sample collection under the instruction of ARRB
  - ARRB and EnRiskS coordinated the laboratory analysis component.

- Stage 4: Conduct a review of the test data obtained in Stage 3 to determine whether RPMs and linemarking paint wash water have the potential to be of concern in relation to human health and the environment, and whether the data supports a different waste classification for disposal.

- Stage 5: Preparation of a technical report (this report), by ARRB detailing a summary of the background, project process and main conclusions of the work conducted by the external consultant.

1.3.1 Suitably Qualified Person Services

Experience and knowledge in toxicology, ecological and human health risk assessment is an area of expertise. As such, Dr Jackie Wright from EnRiskS was engaged to fulfil the role of suitably qualified person (SQP) (as defined in Section 564 of the *Environmental Protection Act 1994*) and to provide advice and technical support during this project.

The SQP scope of work included:

- The preparation of a preliminary technical review relating to the waste classification of the RPMs and linemarking paint wash water, comprising:

  - reviewing the nature of the waste RPMs, identifying the key potential contaminants of concern that are relevant to these materials and identifying the number of samples to be collected and tests required to be undertaken to enable reclassification of RPMs to be considered

  - reviewing the nature of the linemarking paint wash water, including
    - identifying the key potential contaminants of concern that are relevant to these materials and identifying the number of samples to be collected and tests required to be undertaken to enable reclassification of the wash water to be considered
    - identifying available options for the pre-treatment of the wash water
    - conducting an assessment of the differences between linemarking paint and architectural paint and recommendations for tests that could be performed to compare the 2 materials (if appropriate).

- Upon completion of the sampling and laboratory analysis (as recommended in the preliminary technical review), the SQP conducted a review of the laboratory results to determine whether nominated wastes have the potential to be of concern in relation to human health and the environment, and whether the data supports a different waste classification for disposal.

2. Legislation and Other Requirements

This report has been prepared in general accordance with the processes and requirements outlined in current legislation, industry standards and best practice guidelines as set out in:

- Commonwealth
  - ANZG (2018) *Guidelines for Fresh and Marine Water Quality* (ANZG 2018)
  - enHealth (2012) *Environmental Health Risk Assessment – Guidelines for Assessing Human Health Risks from Environmental Hazards* (enHealth 2012)
  - *National Environmental Protection (Assessment of Site Contamination) Measure 1999* (ASC NEPM), National Environment Protection Council (as amended 2013)
- Queensland
  - Department of Environment and Science (DES) (2018), *Monitoring and Sampling Manual*
  - *Environmental Protection Act 1994* (EP Act), State of Queensland
  - *Environmental Protection Regulation 2019* (EP Regulation), State of Queensland
  - Queensland Government (2019) *Queensland Waste Management and Resource Recovery Strategy*
  - *Waste Reduction and Recycling Act 2011* (WRR Act)
  - *Work Health and Safety Act 2011* (WHS Act)
- TMR specific
  - *Waste 2 Resource Strategy* (TMR 2022)
  - *Waste Reduction and Recycling Plan Annual Status Report* (TMR 2021).

Key elements of these requirements, as related to this assessment, are detailed in the subsequent sections. Shortened versions of the above sources have been used throughout.

2.1 Commonwealth Legislation and Guidelines

Key Commonwealth legislation and guidelines applicable to this preliminary review include the ANZG 2018, enHealth 2012 and ASC NEPM. These documents outline the guiding structure for the investigation and (where applicable) criteria for the assessment of results.

2.2 Queensland Legislative Requirements

2.2.1 General Environmental Duty

At the centre of the EP Act is a general environmental duty which applies to all Queenslanders. Section 319 states that:

> We are all responsible for the actions we take that affect the environment. We must not carry out any activity that causes or is likely to cause environmental harm unless we take all reasonable and practicable measures to prevent or minimise the harm. To decide what meets your general environmental duty, you need to consider:
>
> - the nature of the harm or potential harm
> - the sensitivity of the receiving environment
> - the current state of technical knowledge for the activity

- the likelihood of successful application of the different measures to prevent or minimise environmental harm that might be taken
- the financial implications of the different measures as they would relate to the type of activity.

2.2.2 Waste Classification and Waste Levy

The EP Regulation includes a risk-based waste classification framework where regulated waste is classified as either:

- Category 1 regulated waste (highest risk)
- Category 2 regulated waste (moderate risk), or
- not-regulated waste or general waste (lowest risk).

Schedule 9 of the EP Regulation provides a list of regulated wastes and their default category, wastes that are not regulated waste, and categorisation thresholds for solid and liquid tested waste. Waste generators are responsible for classifying their waste into a risk-based category by either:

- adopting a default waste category from Part 1 of Schedule 9 of the EP Regulation, or
- organising sampling and testing of their waste by an appropriately qualified person to demonstrate an appropriate risk-based category in accordance with Section 43 of the EP Regulation.

This waste classification framework is summarised effectively in the *Overview of Regulated Waste Categorisation* (Department of Environment and Science 2022).

A waste disposal levy framework, informed by the waste classification of the material, is currently in place in Queensland. For example, as of the 2022–23 financial year the levy for Category 1 regulated waste is $175 per tonne, with noted future structured or CPI increases (Queensland Government 2023b). This waste levy structure provides incentive to identify the correct classification of the waste and where possible, the identification of potential waste reuse strategies.

Per- and poly-fluoroalkyl substances

Per- and poly-fluoroalkyl substances (PFAS) are a broad class of anthropogenic substances utilised in a variety of industries and applications. They are emerging contaminants of concern with quantitative laboratory analysis available only for a limited number of PFAS-based analytes. PFAS chemicals including perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexanesulfonic acid (PFHxS) have been identified as being persistent in the environment, bio-accumulative and potentially toxic (Queensland Health 2019). As a result, the regulated waste criteria for PFAS (total) in Queensland is currently set at 0 mg/kg for solid waste or 0 µg/L for liquid waste (Department of Environment and Science 2022). That is, if PFAS is detected above the laboratory's limit of reporting in either solid or liquid waste, the waste will be considered regulated.

PFAS contamination and impact is managed in Australia in accordance with the *PFAS National Environmental Management Plan* (PFAS NEMP) (Heads of EPA Australia and New Zealand 2020). To guide the sampling and analysis for PFAS contamination, Appendix B of the PFAS NEMP includes a comprehensive list of activities associated with point sources of PFAS contamination and activities associated with PFAS contamination more broadly in Tables B1 and B2 respectively. With respect to the linemarking paint wash water, paints are considered as potentially containing PFAS (as indicated in Table 2.1).

Table 2.1: Potential for PFAS in paints

Activity	Description
Construction industry	Tile coatings, stone coatings, paints, varnishes, sealants, other architectural coatings for films, facades and infrastructure, rigid foams, silicone rubber, thread sealant tapes and pastes and PPE.

Source: Heads of EPA Australia and New Zealand (2020).

2.2.3 End of Waste Framework

Waste is defined in Section 13 of the EP Act as anything that is left over, or an unwanted by-product, from an industrial, commercial, domestic or other activity; or surplus to the industrial, commercial, domestic or other activity generating the waste. Reference is made in this section to the WRR Act which was implemented to:

- promote waste avoidance and reduction, and resource recovery and efficiency actions
- reduce the consumption of natural resources and minimise the disposal of waste by encouraging waste avoidance and the recovery, reuse, and recycling of waste
- minimise the overall impact of waste generation and disposal
- ensure a shared responsibility between government, business and industry and the community in waste management and resource recovery
- support and implement national frameworks, objectives and priorities for waste management and resource recovery.

It is under the WRR Act where an end of waste framework has been established. Where the use of a waste as a resource has been demonstrated to have benefits through sustainable use and negligible risks to human health and the environment, government may consider developing an end of waste code (EOW code) (Queensland Government 2023a). This document states the conditions for the use of the resource.

Where there is interest to test the feasibility for a waste to become a marketable resource, but no EOW code has been developed, waste producers can apply for an end of waste approval (Queensland Government 2022). This instrument is issued by government on a trial basis for reusing waste as resources and only extends for the length of time required to undertake the trial. The government then considers the findings of the trial (e.g. benefits, sustainability, environmental impacts and environmental best practice) prior to deciding whether an EOW code should be developed for that waste type.

The end of waste framework may be an avenue for consideration should reuse opportunities arise for the waste RPMs and linemarking paint wash water.

3. Linemarking Paint Wash Water

3.1 Wash Water Waste Classification

3.1.1 Preliminary Technical Review

EnRiskS was engaged by ARRB to complete a preliminary technical review of the linemarking paint wash water. The EnRiskS report, *Regulated Waste Interim Technical Review: Reducing Waste Disposal from Raised Pavement Markers and Wash Waters Derived from Line Marking Paint* has been included as an appendix to the final EnRiskS report in Appendix A. The following summary of that report relates to the linemarking paint wash water portion only.

The linemarking paint wash water is currently disposed of as Category 2 regulated waste under the default waste categorisation item 70 – *waste from the manufacture, formulation or use of inks, dye, pigments, paints, lacquers or varnish* (DES 2022). As outlined in Section 1.2, Project Purpose and Objectives, the aim of this investigation is to confirm if that classification is correct, and to identify if there are other potential disposal options. Information relating to two water-based paints, typically used by TMR for linemarking, were provided to EnRiskS by ARRB for the purposes of this review.

The safety data sheets (SDS) for these paints were reviewed and form part of the assessment as shown in the EnRiskS report. The key chemicals of relevance and their potential environmental and human health risks, as listed on the SDS and identified by EnRiskS are summarised in Table 3.1.

Table 3.1: Key wash water chemicals of relevance as identified in the SDS of two water-based paints

Key chemical	Description	Human health and environmental risk
Ammonia	Volatile substance, not anticipated to be present at high concentrations in the wash water.	Low
Polymer latex	Paint forming chemical.	Low
Calcium carbonate	Paint forming chemical.	Low
Propylene glycol	Synthetic liquid substance that absorbs water and maintains moisture. It is commonly used in medicines, cosmetics and food products.	Low
2,2,4-trimethyl-1,3-pentanediol monoisobutyrate	Volatile organic compound (VOC) found in paints and printing inks as a coalescing agent. It is present in polypropylene packed food product and floats on water. It is also found in coating products, polishes, waxes, washing and cleaning products, biocides, plant protection products, adhesives and sealants. It is readily biodegradable in freshwater.	Low
Titanium dioxide	Naturally occurring oxide present in paints, fillers, adhesives, food and cosmetic/sunscreen colours.	Low

Source: Adapted from EnRiskS (2023) (Appendix A).

The literature review conducted by EnRiskS concluded there is a potential for additional chemicals not listed on the SDS to be present in the paint. These chemicals include toluene, xylene, aliphatic hydrocarbons, ketones, alcohols, esters, glycol ethers, amines, ammonia, amides, formaldehyde, ethylene glycol, mercury compounds, methyl cellulose, phenols, and chlorinated compounds. Based on the review, testing for all chemicals as listed in Schedule 9 of the EP Regulation was recommended, with the exception of:

- peroxides
- asbestos
- fluoride
- polycyclic aromatic hydrocarbons (PAH)

- dinitrotoluene
- specific persistent organic pollutants (POPs).

EnRiskS further recommended that testing for per- and poly-fluoroalkyl substances (PFAS) be included within the analysis suite. As outlined in Appendix B, Table B2 of the PFAS NEMP (Heads of EPA Australia and New Zealand 2020), paints are included as potentially containing PFAS (Table 2.1). In accordance with waste categorisation requirements in Queensland, the analysis of PFAS total oxidisable precursor assay (TOPA) was also recommended (Department of Environment and Science 2022).

In addition to the above, the following analysis was also recommended by EnRiskS:

- ammonia: due to the use of the ammonia float solution
- biological oxygen demand (BOD), chemical oxygen demand (COD) and suspended solids (SS): to assess the potential for disposal of the wash water to trade waste.

Wash water treatment methods

In addition to the literature review and provision of advice for the sampling and analysis of the linemarking wash water, EnRiskS completed an analysis of the potential methods to separate the solids from paint. The following 3 main methods were identified:

- nanotechnology
- membrane separation
- coagulants and flocculants.

These methods are summarised in Table 3.2.

Table 3.2: Summary of wash water treatment methods

Method	Summary of process	Suitability for adoption
Nanotechnology	Converts harmful dyes into less harmful products via photocatalytic processes.	May result in residual toxic effects. May be difficult to scale to an industrial scale.
Membrane separation	Wastewater is driven through a membrane under the driving force of pressure, electrical potential, or concentration gradient (Hansen & Cheong 2019). The choice of membrane process selected is usually determined by factors such as particle size and the chemical nature of the material requiring separation.	Membrane separation technology presents an opportunity for further investigation, however as the process requires pre-treatment via chemical input and ongoing maintenance (including cleaning), it is unlikely that this method would be suitable for the scale of the (batch) paint wash water treatment required.
Coagulants and flocculants	A coagulant is mixed with a wastewater to neutralise the negative charges and allow flocculation, the process where contaminants absorb to each other. Larger particles form and settle.	Currently being trialled via the purchased chemical treatment system (refer below).

Source: Adapted from EnRiskS (2023) (Appendix A).

RoadTek sites in Sunshine Coast and Toowoomba have purchased standard chemical treatment systems which can be used to separate out the solid components from the liquid waste produced from washing down linemarking equipment. This system utilises aluminium-based coagulants and flocculants to separate the solids in combination with sodium carbonate to adjust the pH of the treated wastewater. A paint manufacturer was contacted during the investigation to determine the treatment systems used; however, no information was able to be provided.

Although these systems have been purchased, there has been mixed feedback on how well the systems separate the solids from the liquid, to recover and reuse the water and pump the sludge into drying containers. Disposal costs can be decreased if the water can be extracted from the liquid waste and the resulting solid waste is disposed of. The wash water treatment system technical support component of this project has not been included within the scope of this report.

Industrial versus architectural or decorative paint

In accordance with Queensland legislation, industrial waste is considered a default regulated waste, whereas architectural or decorative paint is not. EnRiskS identified the following possible reasons for this dichotomy:

- Industrial paints may be produced and/or used in larger volumes.
- Industrial paints may contain different chemicals to architectural or decorative paints (e.g. metals or higher concentrations of solvents) as they are developed for specialist applications.
- Industrial paints may be used with other additives.

To support a comparison between industrial and architectural or decorative paint, EnRiskS conducted an analysis of the information contained within an SDS for representative of an industrial paint and an SDS representative of an architectural or decorative paint. example of both paint types.

The EnRiskS report noted both paints are marked ‘non-hazardous chemical’, ‘non-dangerous goods’ and no ingredients listed were considered hazardous. A further review of both SDS highlighted limited differences between the 2 paints. To confirm there are limited differences between the 2 paints, EnRiskS recommended sampling and laboratory chemical analysis be conducted on both paints. These recommendations are further discussed in Section 5.

3.1.2 Wash Water Sampling

As an output of the technical review, EnRiskS recommended 3 linemarking paint wash water samples be collected and submitted to the nominated NATA accredited laboratory (Envirolab) for analysis. One sample was to be analysed for the following analytes, with the remaining 2 samples being placed on hold pending a review of the results:

- concentrations of key chemicals in Table 4a and Table 4b of Appendix 4 of DES (2022), excluding:
  - peroxides
  - asbestos
  - fluoride
  - polycyclic aromatic hydrocarbons (PAH)
  - dinitrotoluene
  - specific persistent organic pollutants (POPs)
- PFAS and PFAS TOPA
- ammonia
- COD and suspended solids.

To enable a cost-effective and efficient sample collection regime, all samples were collected by RoadTek under instruction from ARRB. To ensure the linemarking paint wash water samples were collected in accordance with current industry standards and best practice, ARRB developed and supplied RoadTek with sampling instructions (Appendix B). These sampling instructions outlined:

- sampling containers and appropriate labelling protocols
- number of samples to be collected
- cross-contamination prevention measures
- quality control and transportation requirements.

Three linemarking paint wash water samples were collected from the RoadTek Greenwattle Street depot, Wilsonton, Toowoomba on 17 November 2022 by RoadTek in accordance with the aforementioned sampling instructions. All samples were collected in the laboratory-supplied containers from the linemarking washdown and storage area (Figure 3.1).

The collected samples were then placed in a chilled cooler and delivered to the ARRB office in Brisbane for collation and preparation of the laboratory's chain of custody (COC).

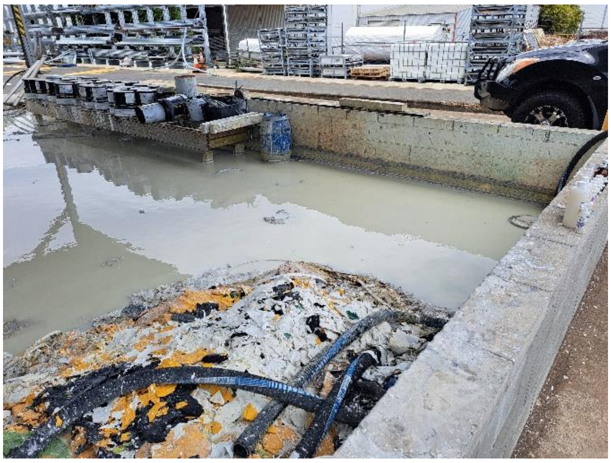
Figure 3.1: Toowoomba linemarking washdown and storage area

Source: TMR supplied.

The linemarking paint wash water samples were DSW1, DSW2 and DSW3.

The origin of the wash water was from the washdown (cleaning) of the longline machine and other linemarking equipment that had been working throughout the Downs Southwest (DSW) Region in various locations. As such, the wash water within the pit was comprised of wash water from various locations and various dates, prior to 17 November 2022. The collection point for samples DSW1 and DSW2 is shown in Figure 3.2. Bottled samples for DSW1 and DSW2 are shown in Figure 3.3 and Figure 3.4 respectively.

Figure 3.2: Sampling point for DSW1 and DSW2



Source: TMR supplied.

Figure 3.3: DSW1 bottled samples

Source: TMR suppled.

Figure 3.4: DSW2 bottled samples

Source: TMR supplied.

Sample DSW3 was collected from 1 of 4 (1,000 L) intermediate bulk containers (IBCs) adjacent to the linemarking washdown and storage area (Figure 3.5). The wastewater in all 4 IBCs was decanted from the washdown pit. Bottled samples are shown in Figure 3.6.

Figure 3.5: IBCs adjacent to washdown pit

Source: TMR supplied.

Figure 3.6: Bottled wastewater sample DSW3

Source: TMR supplied.

3.1.3 Laboratory Analysis

Three linemarking paint wash water samples were submitted to Envirolab for analysis via courier on 21 November 2022. In line with the recommendations in the EnRiskS report (Appendix A), one sample (DSW1, selected at random) was nominated for preliminary analysis, with the remaining 2 samples being placed on hold.

The Envirolab laboratory documentation is included within the EnRiskS assessment report included in Appendix A.

3.1.4 Assessment Results

The following summary is based on and adapted from the EnRiskS assessment of the results (Appendix A).

The following key chemicals were detected in the wash water:

- phenol and m/p-cresol
- PFAS
- ammonia
- metals (arsenic, barium, boron, cadmium, total chromium, copper, nickel and lead).

Of these key chemicals PFAS, copper and zinc were noted to exceed the Queensland regulated waste criteria (Department of Environment and Science 2022). Physical parameters including electrical conductivity (Ec) and biological oxygen demand (BOD) were also noted to exceed the Queensland regulated waste criteria (Department of Environment and Science 2022). These exceedances are displayed in Table 3.3.

Table 3.3: Wash water regulated waste criteria exceedances

Analyte	Units	Qld regulated waste criteria(1)	Results: sample DSW1(2)
PFAS	µg/L	< 0	1.9
Copper	µg/L	< 14	49
Zinc	µg/L	< 30	280
Ec	µS/cm	< 1,200	2,100
BOD	mg/L	< 15	5,170

1. Qld regulated waste criteria sourced from Department of Environment and Science (2022).
2. NATA laboratory reports are included within Appendix A. Results exceeding nominated criteria are displayed in red.

As outlined in the EnRiskS report (Appendix A) PFAS was analysed for completeness, not because it was an expected potential contaminant of concern within the wash water. The detected PFAS compounds are the C4 to C7 carboxylic acids, with the compounds primarily dominant within firefighting foams (i.e. perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS) and perfluorooctanoic acid (PFOA) reported below the laboratory's level of reporting (LOR) of < 0.1 µg/L. As such, it is possible that the source of the PFAS within the wash water may be due to a presence in the paint, or cross-contamination during preparation, use, storage and/or handling. It is noted that several of the LORs for PFAS were raised due to matrix interference. For example, the LOR for PFOS, PFHxS and PFOS is 0.1 µg/L, which is significantly above the target LOR of 0.0002 µg/L.

Other key chemicals detected within the wash water that were found to exceed the nominated criteria include copper, zinc, Ec and BOD.

3.1.5 Waste Categorisation

The regulated waste criteria for liquids in Queensland consists of a regulated or non-regulated threshold. As several analytes exceed this threshold, the linemarking paint wash water remains categorised as regulated as per the initial default characterisation.

3.1.6 Recommendations

The outcomes of the assessment indicate that the wash water is to remain regulated as per the liquid waste criteria. A modification to this outcome may be possible by undertaking more detailed investigations and characterisation works. Should TMR wish to pursue these additional investigation works, the following actions may assist in the development of an investigation action plan:

- Request information from suppliers on whether PFAS are present in the water-based paints used for line marking, including whether it has any laboratory analysis data to confirm the presence or absence at the LOR that is possible for the waste (i.e. in consideration of matrix interference).
- Confirm the wash water life cycle to determine the key stages where PFAS may be added to the wash water i.e. which products are used in the process, where do these products come from, and might they contain PFAS?
- Review procedures at storage and handling sites to identify if there is the potential for environmental cross-contamination.
- Analyse samples of the products from the key life-cycle stages for PFAS. ARRB and TMR could also consider analysing wash water sourced from domestic house paints for PFAS. Where PFAS is detected in wash water from domestic paints, a further discussion in relation to the relevance of the detection of PFAS in wash water from linemarking paints could be initiated with DES.

4. Raised Pavement Markers

4.1 RPM Waste Classification

4.1.1 Technical Review

EnRiskS was engaged by ARRB to complete a technical review of the RPMs and the applicable waste and potential reuse applications. The EnRiskS report, *Regulated Waste Interim Technical Review: Reducing Waste Disposal from Raised Pavement Markers and Wash Waters Derived from Line Marking Paint* has been included as an appendix to the final EnRiskS report in Appendix A. The following summary of that report relates to the RPM portion only.

The waste RPMs are currently disposed of as Category 1 regulated waste under the default waste categorisation item 59 – *tarry residues arising from refining, distillation or any other pyrolytic treatment* (DES 2022). As outlined in Section 1.2, Project Purpose and Objectives, the aim of this investigation is to confirm if that classification is correct, and to identify if there are other potential disposal options.

Information provided by ARRB to EnRiskS to support the technical review included:

- RPMs typically comprise a plastic body with a coated acrylic lens.
- The bitumen adhesive comprises bitumen (petroleum) (25–40% by weight) and calcium carbonate (55–70% by weight).

The Queensland Government provides an *End of Waste Code. Recycled Aggregates (ENEW07604819)* (Department of Environment and Science 2021) under the *Waste Reduction and Recycling Act 2011*. This includes the use of reclaimed asphalt pavements as a resource for engineering purposes in building, construction (which includes road and/or railway construction and maintenance) and/or landscaping applications. There are no guidelines for chemicals (including petroleum hydrocarbons) in the code. There does not appear to be any difference in the use of bitumen as an adhesive for affixing RPM to a road and the use of bitumen in asphalt to construct a road. Hence, the code appears applicable to waste RPM. It is noted, however, in accordance with Section 6.3(b), that it is required that 'all reasonable and practicable measures have been taken to ensure that recycled aggregates are segregated from other waste material'.

The SDS for a typical RPM and bitumen adhesive formed part of the assessment as shown in the EnRiskS report The key chemicals of relevance and their potential environmental and human health risks, as listed on the SDS and identified by EnRiskS are summarised in Table 4.1.

Table 4.1: Key chemicals of relevance in RPMs as identified in the SDS

Key chemical	Rationale
Petroleum hydrocarbons	Main chemical in bitumen
Polycyclic aromatic hydrocarbons	Main chemical in bitumen
Heavy metals	Bitumen may contain metals
Aliphatic and aromatic hydrocarbons	Bitumen contains other hydrocarbons
Phenols	Bitumen may contain phenols
Other – pH	Recommended for reuse assessment

Source: Adapted from EnRiskS (2023) (Appendix A).

4.1.2 Sampling and Analysis

As an output of the technical review, EnRiskS recommended three 1 kg batches of RPM samples be collected and submitted to the nominated NATA accredited laboratory (Envirolab) for analysis. Sample batches were to be collected from Rockhampton, the Gold Coast and Toowoomba to allow for the variability in the materials being assessed. One sample was to be analysed for the following analytes, with the remaining 2 samples being placed on hold pending a review of the results:

- total petroleum hydrocarbons (TPH)
- total recoverable hydrocarbons (TRH)
- monocyclic aromatic hydrocarbons (MAH)
- phenols
- metals
- pH.

To enable a cost-effective and efficient sample collection regime, all samples were collected by RoadTek under the instruction of ARRB. To ensure waste RPM samples were collected in accordance with current industry standards and best practice, ARRB developed and supplied RoadTek with sampling instructions (Appendix B). The sampling instructions outlined:

- sampling containers and appropriate labelling protocols
- number of samples to be collected
- cross-contamination prevention measures
- quality control and transportation requirements.

Toowoomba

All samples were collected from the RoadTek Greenwattle Street depot, Wilsonton, Toowoomba. The RPMs were collected from skip bins awaiting disposal (Figure 4.1). The origins of the RPMs are various from locations throughout the Downs Southwest and Gold Coast Regions. A sample of 10 RPMs was provided to ARRB for analysis (Figure 4.2).

The sample was collected in a clean zip lock bag on 17 November 2022 by RoadTek in accordance with the aforementioned sampling instructions. The collected sample was then delivered to the ARRB office in Brisbane for collation and preparation of the laboratory's chain of custody (COC).

Figure 4.1: RPMs in waste container

Source: TMR supplied.

Figure 4.2: RPMs provided for analysis

Source: TMR supplied.

Gold Coast

The Gold Coast RPM sample was collected on 8 November 2022 from the linemarking regulated waste storage bin located at RoadTek's Gold Coast depot at 186-200 Banyula Drive, Nerang.

The Gold Coast RPM sample contained 10 RPMs and they were collected and labelled in accordance with the provided sampling instructions. The sample collection process and waste storage facilities are shown in Figure 4.3 to Figure 4.6 .

The collected sample was then delivered to the ARRB office in Brisbane for collation and preparation of the laboratory's COC.

Figure 4.3: Collection of RPMs with nitrile gloves from linemarking regulated waste storage bin

Source: TMR supplied.

Figure 4.4: Sealed and labelled sample bag of 10 x RPMs from linemarking regulated waste storage bin

Source: TMR supplied.

Figure 4.5: Linemarking regulated waste storage bin (RPM sampling location)

Source: TMR supplied.

Figure 4.6: Sealed and labelled sample of 10 x RPMs to be delivered.

Source: TMR supplied.

Rockhampton

The Rockhampton RPM sample was collected on 7 November 2022 from the linemarking regulated waste storage bin located at RoadTek's Rockhampton depot at 214 Richardson Road, Park Avenue.

The sample contained 10 RPMs and they were collected and labelled in accordance with the provided sampling instructions. The waste storage bin is shown in Figure 4.7 .

The collected sample was then delivered to the ARRB office in Brisbane for collation and preparation of the laboratory's COC.

Figure 4.7: Rockhampton regulated waste storage bins

Source: TMR supplied.

4.1.3 Laboratory Preparation and Analysis

Images of the RPMs as received at the Envirolab laboratory are shown in Figure 4.8, Figure 4.9 and Figure 4.10. As the RPMs were too hard to crush via standard conventional methods (e.g. hammer or tomahawk and chipper) it was deemed not feasible to crush and analyse all 10 RPMs in the batch. It was agreed between EnRiskS, Envirolab, ARRB and TMR that 2 RPMs (per site or sample) were selected (chosen based on representativeness of the entire sample batch) for crushing and analysis, ensuring each element (i.e. RPM and bitumen) would be included. It is noted that Envirolab utilised liquid nitrogen to assist in the crushing and breaking down of the RPMs for analysis.

One sample (Rockhampton, selected as it was considered the most variable) was nominated for preliminary analysis, with the remaining 2 samples (Gold Coast and Toowoomba) being placed on hold. Following receipt of the results from the analysis of the Rockhampton samples, total concentration for the remaining 2 samples and Australian standard leachate procedure (ASLP) analysis was requested.

The Envirolab laboratory documentation is included within the EnRiskS assessment report included in Appendix A.

Figure 4.8: Toowoomba RPMs

Source: Envirolab supplied.

Figure 4.9: Gold Coast RPMs

Source: Envirolab supplied.

Figure 4.10: Rockhampton RPMs

Source: Envirolab supplied.

4.1.4 Assessment Results

The following summary is based on and adapted from the EnRiskS assessment of the results (Appendix A).

The following key chemicals were detected in the RPMs:

- toluene, ethylbenzene, styrene
- naphthalene
- phenol
- copper
- vanadium
- total petroleum hydrocarbons (TPH) / total recoverable hydrocarbons (TRH).

Of these key chemicals pH and TPH only were noted to exceed the Queensland regulated waste criteria (Department of Environment and Science 2022). These exceedances are displayed in Table 4.2. The ASLP results (not displayed) indicated that the TPH detected is not leachable.

Table 4.2: RPM regulated waste criteria exceedances

Analyte	Units	Qld regulated waste criteria(1)		Results(2)		
		Category 2	Category 1	Rockhampton	Gold Coast	Toowoomba
pH	mg/kg	2 – < 6.5 or > 9–12.5	< 2 or > 12.5	9.4	10.2	9.0
TPH (C10 to C36)	mg/kg	5,300–21,200	> 21,200	7,800	15,000	5,700

1. Qld regulated waste criteria sourced from Department of Environment and Science (2022).
2. NATA laboratory reports are included within Appendix A. Results exceeding nominated criteria are displayed in red.

4.1.5 Waste Categorisation

The regulated waste criteria for solid waste in Queensland consists of a risk-based classification:

- Category 1 regulated waste (highest risk)
- Category 2 regulated waste (moderate risk), or
- not-regulated waste or general waste (lowest risk).

Both pH and TPH were noted to exceed the threshold for Category 2 waste, however, were below the Category 1 criteria. Although originally classified as Category 1 via the default categorisation, the results of the sampling and analysis conducted indicates that the RPMs can be disposed of as Category 2 regulated waste.

4.1.6 Recommendations

There are no recommendations arising from this section of the review.

4.2 Risk Assessment for Beneficial Reuse of RPMs

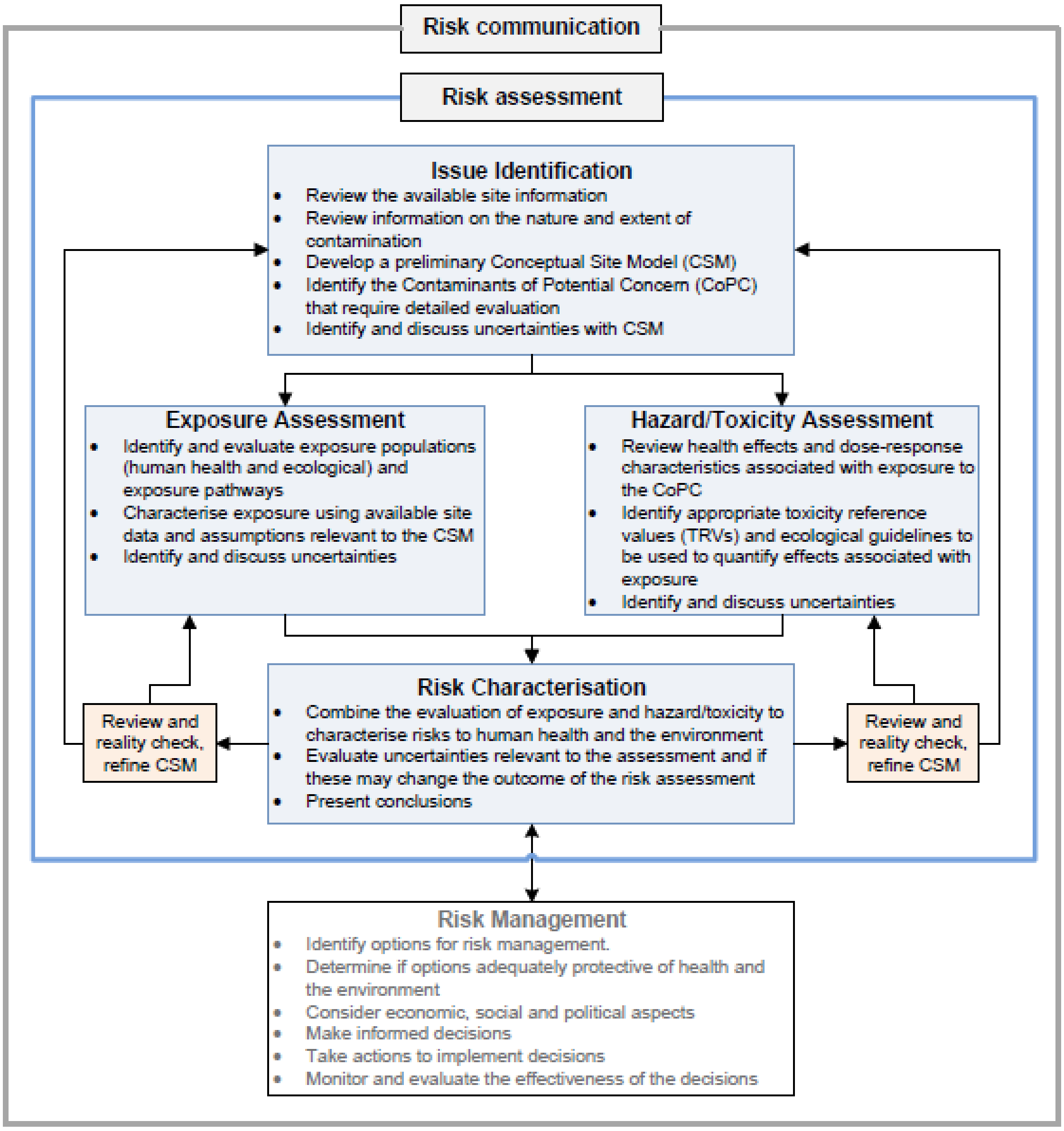
Potential beneficial reuse applications of waste RPMs have been reviewed as a part of the EnRiskS assessment. The agreed beneficial reuse applications for consideration include:

- Application 1 – partial aggregate replacement in asphalt.
- Application 2 – use in materials underlying asphalt (encapsulating the waste RPM, where a fresh asphalt is laid over an old asphalt layer with RPMs affixed).

Neither application is expected to change the chemical characteristics of the materials. As such, the human health and environmental risks are not expected to change. Application 2 is considered a less sensitive scenario from a human health and ecological perspective.

To assess the potential risks associated with the beneficial reuse of the waste RPMs, a human health and ecological risk assessment (HHERA) has been undertaken on Application 1 (i.e. the reuse scenario with a more sensitive risk to human health and the environment). The HHERA approach undertaken was adapted from enHealth (2012) and is shown in Figure 4.11.

Figure 4.11: HHERA framework



Source: EnRiskS (2023) (Appendix A).

The outcomes of the HHERA are summarised in Table 4.3. Complete details are available in Appendix A.

Table 4.3: RPM reuse HHERA summary

	Exposure pathways		
Identified receptor(s)	**Total concentration**	**Leachable concentration**	**HHERA outcome**
Workers (adults)	• Incidental ingestion • Dermal contact • Inhalation of dust	*Pathway incomplete – due to solidification/binding processes utilised in incorporating the waste RPMs in the road*	Total concentrations of all chemicals in waste RPMs are below the adopted screening guidelines. As such, there are no health risk issues of concern to workers
Members of the general public (adults and children)	• Pathway incomplete – members of the public are not expected to be directly exposed to waste RPMs		N/A
The environment (i.e. terrestrial and aquatic ecosystems at and/or downgradient of the reuse site as well as any intermediate storage or transport sites)	• Pathway incomplete – terrestrial and aquatic ecosystems are not expected to be directly exposed to total concentrations of waste RPMs		N/A

Source: Adapted from EnRiskS (2023) (Appendix A).

The HHERA demonstrates that the only complete exposure pathway which has the potential to impact on human health or the environment is to the workers (adults) who may be involved in handling the waste RPMs. The subsequent quantitative assessment performed on this receptor indicated that the risks to workers were minimal as the total concentrations of all chemicals in the waste RPMs were below the adopted screening guidelines.

In addition to the chemical contaminants, the pH of the material was also assessed. The pH reported for the RPM material is shown in Table 4.4. The reported pH is noted to be alkaline and exceeding the adopted screening level.

Table 4.4: RPM pH summary

Chemical (or indicator)	Total concentration in the waste RPM	Adopted screening level guideline (workers, direct contact)
pH (units)	9.0–10.2	6–8

Source: Adapted from EnRiskS 2023 (Appendix A).

The potential hazards associated with an alkaline pH are skin irritation and burns. An additional review of supporting guidance indicated that pH values less than 4 and greater than 11 may result in dermal effects (NHMRC & NRMMC 2011). As the reported pH of the waste RPMs is within that nominated range, no adverse health effects are expected from handling the material.

4.3 End of Waste Considerations for RPMs

As discussed in Section 2.2.3, an end of waste framework has been enabled under the WRR Act. Where the use of a waste as a resource has been demonstrated to have benefits through sustainable use and negligible risks to human health and the environment, government may consider developing an end of waste code (EOW code) (Queensland Government 2023a). This document states the conditions for the use of the resource.

Where there is interest to test the feasibility for a waste to become a marketable resource, but no EOW code has been developed, waste producers can apply for an end of waste approval (Queensland Government 2022). This instrument is issued by government on a trial basis for reusing waste as resources and only extends for the length of time required to undertake the trial. The government then considers the findings of the trial (e.g. benefits, sustainability, environmental impacts and environmental best practice) prior to deciding whether an EOW code should be developed for that waste type.

The end of waste considerations for waste RPMs and the appropriateness of applying for an EOW approval have been assessed by EnRiskS. It has been assumed that if the waste RPMs are to be used in recycled aggregates (as opposed to in asphalt, noted in Section 4.2), 2 key end of waste exposure scenarios exist:

- reuse of recycled aggregates in unbound applications, where the run-off and/or leaching of chemicals to the environment may occur
- reuse of recycled aggregates underneath buildings, where concentrations of VOCs in the materials could intrude into overlying enclosed spaces.

4.3.1 Unbound Reuse

For the application of recycled aggregates containing waste RPMs, exposure to contaminants of concern could occur via incidental ingestion and/or dermal contact due to leaching and/or run-off to groundwater or surface water where that water is used by humans or an aquatic ecosystem that requires protection is present. The potential for surface water run-off will depend on the extent and permeability of overlying materials covering the aggregates containing waste RPMs. Similarly, the potential for leaching of the materials will also depend on the porosity, infiltration rate and subsequent permeability of the materials.

Use of the aggregates containing waste RPMs will have the highest potential for leaching and surface water runoff. The concentration of contaminants measured within the leachate is unlikely to be the concentration of contaminants detected at the point of human or ecological exposure due to the physical, chemical and biological processes that are likely to occur. As such, EnRiskS has applied a dilution factor to the leachate results in accordance with guidance detailed in the ASC NEPM.

The human health risk assessment, applying the dilution factor, determined that there are no human health risk issues of concern for members of the public and the use of waste RPMs in aggregates. Similarly, the ecological risk assessment determined there are no risk issues of concern to aquatic ecosystems through the use of the waste RPMs in aggregates.

A detailed description of the human health and ecological risk assessment undertaken is available in the EnRiskS report in Appendix A.

4.3.2 Use of Aggregates with Waste RPM Underneath Buildings

Contaminants of concern including VOCs, benzene, ethylbenzene, toluene and TRH have been detected within the waste RPM. VOCs and TRH have been detected at concentrations exceeding guideline values, and as such there is potential for vapour intrusion into the building.

It is not anticipated that the volume of waste RPMs in aggregates utilised underneath buildings would be sufficient for vapour intrusion risks to occur, however the risks associated with this type of reuse have not been included within the scope of this assessment.

5. Conclusions and Recommendations

The primary purpose of this project was to assess the waste RPMs and linemarking paint wash water to determine if the waste category can be changed from regulated waste to non-regulated waste. If the waste categories can be changed, it will allow RoadTek to reduce disposal costs and may enable these materials to be recycled in the future.

The project also included a review of options which could be used to separate the paint solids from the liquid components in the washings from linemarking equipment and determine if there is a difference between linemarking paint and architectural paint (which is not classified as regulated waste).

The following key scope items required by the project have been addressed:

- Stage 1: Paint wash water treatment technical support.
- Stage 2: A preliminary technical review of RPMs and linemarking paint wash water.
- Stage 3: Laboratory analysis of samples.
- Stage 4: Data review and final waste classification assessment.
- Stage 5: Preparation of the final technical report (this report).

The preliminary technical review identified the current status of the waste RPMs and waste linemarking paint wash water, including the current waste classification and the potential contaminants of concern present within the materials. The technical review provided a summary of potential treatment methods for the paint wash water, including:

- nanotechnology
- membrane separation
- coagulants and flocculants.

Further, a comparison of the status of industrial and architectural or decorative paints was undertaken as industrial waste is considered regulated, whereas architectural or decorative paints are considered non-regulated. EnRiskS identified the following possible reasons for this dichotomy:

- Industrial paints may be produced and/or used in larger volumes.
- Industrial paints may contain different chemicals to architectural or decorative paints (e.g. metals or higher concentrations of solvents) as they are developed for specialist applications.
- Industrial paints may be used with other additives.

Sampling and laboratory analysis of the waste materials was conducted to confirm the extent of the potential contaminants of concern present, and to provide a basis for comparison against current accepted waste classification standards and guidelines. The outcomes of the sampling and laboratory analysis indicated:

- The linemarking paint wash water will remain classified as regulated as per the initial assessment based on the presence of detected PFAS, copper, zinc, Ec and BOD.
- The waste RPMs will remain classified as regulated, however the classification can be lowered from Category 1 to the less hazardous Category 2. The potential contaminants of concern detected within the waste RPMs include pH and TPH.

A risk assessment for the beneficial reuse of the waste RPMs was undertaken for the assessment of:

- Application 1 – partial aggregate replacement in asphalt
- Application 2 – use in materials underlying asphalt (encapsulating the waste RPM, where fresh asphalt is laid over older asphalt with RPMs affixed).

An additional end of waste assessment for the use of waste RPMs in unbound applications was also undertaken. All human health and ecological risk assessments determined that the material is suitable for reuse in the proposed applications. Due to the presence of VOCs and TRH exceeding nominated guidelines, the material is not considered suitable for use underneath buildings without further assessment.

5.1 Recommendations

The following recommendations are made based on the assessment presented.

5.1.1 Disposal of Wash Water

The outcomes of the assessment indicate that the wash water is to remain regulated as per the liquid waste criteria. A modification to this outcome may be possible by undertaking more detailed investigations and characterisation works. Should TMR wish to pursue these additional investigation works, the following actions may assist in the development of an investigation action plan:

- Request information from suppliers on whether PFAS are present in the water-based paints used for line marking, including whether they have any laboratory analysis data to confirm presence or absence.
- Confirm the wash water life cycle to determine the key stages where PFAS may be added to the wash water i.e. which products are used in the process, where do these products come from and might they contain PFAS?
- Review procedures at storage and handling sites to identify if there is the potential for environmental cross-contamination.
- Analyse samples of the products from the key life-cycle stages for PFAS.

5.1.2 Disposal of Waste RPM

No recommendations.

5.1.3 Reuse of Waste RPM for Applications 1 and 2

No recommendations.

5.1.4 Reuse of Waste RPM in Recycled Aggregates

- Waste RPMs are not suitable for use in recycled aggregates placed underneath buildings without further information or assessment.

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Appendix A EnRiskS Regulated Waste Technical Review

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18 September 2023

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Regulated waste interim technical review: reducing waste disposal from raised pavement markers and wash waters derived from line marking paint

1.0 Introduction and background

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by the Australian Road Research Board (ARRB), on behalf of the Queensland Department of Transport and Main Roads (TMR), to undertake a technical review and provide advice in relation to the disposal and/or beneficial re-use of:

- waste created during the removal of raised pavement markers from roads (waste RPM)
- wash water derived from the use of line marking paint (wash water).

Both materials are currently disposed as regulated waste in Queensland. Waste RPM are disposed of as Category 1 regulated waste under default waste categorisation item 59 - *tarry residues arising from refining, distillation or any other pyrolytic treatment* (DES 2022). Item 59 has been selected by ARRB as a bitumen adhesive is used to affix the RPM to the road, and a small amount of the adhesive as well as residual bitumen is unable to be removed from the waste RPM. Wash water is disposed of as Category 2 regulated waste under default waste categorisation item 70 - *waste from the manufacture, formulation or use of inks, dyes, pigments, paints, lacquers or varnish* (DES 2022).

Exhibit 1.1 shows photographs relevant to the wastes being reviewed.

Exhibit 1.1. Photographs (provided by ARRB) of wastes being reviewed in this letter comprising 1) waste generated following RPM removal, and 2) typical wash bay where line marking equipment is washed into a sump and pumped to holding tank for disposal.

ARRB has also requested advice on:

- available methods and/or treatment chemicals that would assist in separating solids from the wash water, for disposal and/or beneficial reuse
- information on the difference between line marking paint and architectural/decorative paint, noting that architectural/decorative paint is not classified as regulated waste in Queensland.

2.0 Objectives

The objectives of the technical review presented in this report are to:

- identify the key chemicals relevant to waste RPM from the categorisation thresholds for solid tested waste in Appendix 3 of DES (2022)
- identify any other key chemicals or analysis types relevant to the beneficial re-use of waste RPM
- identify the key chemicals relevant to the wash water from the categorisation thresholds for liquid tested waste in Appendix 4 of DES (2022)
- identify any other key chemicals or analysis types relevant to the beneficial re-use of wash water
- undertake a search of the scientific literature to source information on available methods and treatment chemicals that may assist in separating solids from the wash water
- undertake a search of the scientific literature to identify any published differences between line marking paint and architectural/decorative paint.

This assessment based on information provided by ARRB and available in the scientific literature to 14 October 2022, as relevant to the disposal and/or beneficial re-use of waste RPM and wash water. The review has considered human health and environmental risk issues associated with beneficial re-use. This assessment does not provide a revised waste categorisation for the above materials or address human health and environmental risks associated with the re-use of waste; these aspects are proposed to be addressed in a subsequent assessment when more information is available in relation to the presence of chemicals in waste RPM and wash water.

3.0 Key chemicals of relevance

3.1 Waste RPM

General

Information provided by ARRB indicates the following in relation to waste RPM:

- the RPM comprise a plastic body with a coated acrylic lens
- the bitumen adhesive comprises bitumen (petroleum) (25-40% by weight) and calcium carbonate (55-70% by weight) (this information is also shown on the safety data sheet [SDS] for the adhesive).

In relation to the bitumen adhesive, it is important to recognise that bitumen is used as a binder in asphalt (which is a mixture of sand, aggregate and bitumen) as well as concrete, and asphalt can also be used to seal pavements. The Queensland Government provides an End of Waste Code (EoWC) for Recycled Aggregates (ENEW7604819) (Queensland Government 2021) under the Waste Reduction and Recycling Act 2011. This includes the use of reclaimed asphalt pavements as a resource for engineering purposes in building, construction (which includes road and/or railway construction and maintenance) and/or landscaping applications. There are no guidelines for chemicals (including petroleum hydrocarbons) in the EoWC. There does not appear to be any difference in the use of bitumen as an adhesive for affixing RPM to a road and the use of bitumen in asphalt to construct a road. Hence, the EoWC for Recycled Aggregates appears applicable to waste RPM.

It is acknowledged that coal tar was historically used as a binder in asphalt (instead of bitumen), and there are human health and environmental risk issues associated with the presence of coal tar in the environment. However, coal tar is a different material to bitumen – coal tar is a type of creosote that is a by-product of the coal distillation process[1], and bitumen is a by-product of the crude oil distillation process.[2] Coal tar is not listed on the SDS for the bitumen adhesive.

Key chemicals of relevance

Given that bitumen is the key waste of interest in waste RPM, the key chemicals of relevance to waste RPM are petroleum hydrocarbons, specifically petroleum hydrocarbons in the C10 to C36 fraction including polycyclic aromatic hydrocarbons (PAH).

Elevated concentrations of petroleum hydrocarbons (C10-C36) may be present in the waste RPM, due to the presence of bitumen, other petroleum-based compounds or non-petroleum compounds. CRC CARE Technical Report No. 40, *Weathered Petroleum Hydrocarbons (Silica Gel Clean-Up)* (CRC CARE 2018), indicates that weathering processes can result in the formation of polar metabolite compounds (non-petroleum hydrocarbons) that are measured as total recoverable hydrocarbons (TRH) (i.e. petroleum hydrocarbons). Natural organic matter (NOM) may also be present and can contribute to the reported TRH concentration. This can make TRH based risk assessments difficult as it is often assumed that all the reported TRH is petroleum hydrocarbons when some or all of the reported concentration may be metabolites and/or NOM. Silica gel clean-up (SGC) analysis can be used to estimate the concentration of petroleum hydrocarbons versus polar metabolites and NOM in wastes, where the concentration following the SGC analysis is the concentration of petroleum hydrocarbons. Waste RPM are unlikely to contain NOM, however, may contain polar metabolites as a result of weathering. Given this, analysis of waste RPM for TRH following SGC is recommended.

Based on the information publicly available online, it is not possible to exclude the potential that bitumen may also contain metals (including nickel, copper, lead and vanadium) and a range of other aliphatic and aromatic hydrocarbons and phenols. While high concentrations of these chemicals are not expected to be present in waste RPM, analysis for these chemicals is recommended to confirm that they are not present at concentrations that would cause unacceptable human health or environmental risks following waste disposal or beneficial re-use. Similarly, pH analysis is recommended.

Analysis for leachable concentrations of some of the key chemicals (where this analysis is routinely undertaken in Australia) is recommended for any beneficial re-use assessment. Analysis for leachable concentrations should be undertaken using the Australian Standards Leaching Procedure (ASLP) at neutral (environmental) pH.

Table 3.1 summarises the key chemicals of relevance for waste RPM from Table 3a and Table 3b of Appendix 3 of DES (2022), and the recommended analysis for each key chemical.

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[1] Technical Direction 21 Coal Tar asphalt (nsw.gov.au)

[2] https://www.vivaenergy.com.au/blog/innovation/behind-the-bitumen

Table 3.1: Key chemicals of relevance – waste RPM (in order of priority)

Attribute or substance (item number from Appendix 3 of DES 2022)	Rationale	Analysis type	
		Total concentrations	**Leachable concentrations (ASLP at neutral pH)**
Petroleum hydrocarbons			
Petroleum hydrocarbons (C10 to C36) (38)	Main chemical in bitumen	✓	--
Silica gel clean-up (NA)		✓	--
Polycyclic aromatic hydrocarbons			
Benzo(a)pyrene (6)	Main chemical in bitumen	✓	✓
Polycyclic aromatic hydrocarbons (total) (42) [1]		✓	--
Petroleum hydrocarbons			
Petroleum hydrocarbons (C6 to C9) (37)	Bitumen contains other petroleum hydrocarbons	✓	--
Monocyclic aromatic hydrocarbons			
Benzene (5)	Bitumen contains other petroleum hydrocarbons	✓	✓
Toluene (54)		✓	✓
Ethylbenzene (25)		✓	✓
Xylenes (total) (57)		✓	✓
Styrene (vinyl benzene) (44)		✓	✓
Phenols			
Trichlorophenol (2,4,5-trichlorophenol) (52)	Bitumen may contain phenols	✓	✓
Trichlorophenol (2,4,6-trichlorophenol) (53)		✓	✓
Cresol (total) (15)		✓	✓
Phenols (total) (40)		✓	✓
Inorganic species			
Antimony (2)	Bitumen may contain metals	✓	✓
Arsenic (3)		✓	✓
Barium (4)		✓	✓
Beryllium (7)		✓	✓
Boron (8)		✓	✓
Cadmium (9)		✓	✓
Chromium (hexavalent) (13)		✓	✓
Copper (14)		✓	✓
Lead (27)		✓	✓
Mercury (28)		✓	✓
Molybdenum (30)		✓	✓
Nickel (31)	Bitumen may contain metals	✓	✓
Selenium (43)		✓	✓
Silver (45)		✓	✓
Vanadium (55)		✓	✓
Zinc (58)		✓	✓
Other			
pH (1)	Recommended for re-use assessment	✓	--

Notes:
"✓" = indicates analysis recommended.
"--" = indicates analysis not recommended.
NA = indicates not applicable.
1 = sum of acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenzo(ah)anthracene, fluoranthene, fluorene, indeno(a,2,3-cd)pyrene, naphthalene, phenathrene and pyrene.

<u>Recommended analysis approach</u>

The following approach is recommended for the analysis of waste RPM:

1. Provision of 3 x 1 kg samples of waste RPMs to Envirolab Services (Envirolab) for analysis i.e. plastic body plus bitumen plus adhesive and 1 kg of waste RPM from each of Rockhampton, the Gold Coast and Toowoomba. It is recommended that the samples encompass the amount of bitumen and adhesive that is usually present on waste RPM, and the age of the waste RPM, so an indication of variability can be obtained.
2. Analysis of 1 x 1 kg sample of waste RPM, with the most bitumen and adhesive, for the following (remaining 2 samples to be kept on hold by the laboratory):
    a) total concentrations of key chemicals listed in **Table 3.1**
    b) SGC.
3. Review of sample results by enRiskS to confirm that there is nothing unexpected that may impact on waste classification and beneficial re-use (e.g. significantly elevated concentrations of metals) and confirm which chemicals to analyse for ASLP (noting that ASLP analysis is not necessary where a key chemical is not detected in waste RPM above the laboratory limit of reporting).
4. Analysis of remaining 2 x 1 kg samples of waste RPM for:
    a) total concentrations of key chemicals listed in **Table 3.1**
    b) SGC.
5. Analysis of all 3 x 1 kg samples of waste RPMs for leachable concentrations of key chemicals listed in **Table 3.1**, and where the key chemical is detected in the waste RPM at steps 2a.

Steps 4 and 5 would be completed concurrently.

The above approach is suggested as the most cost-effective way to undertake the analysis, as it will identify any unexpected chemical concentrations early and also provide an opportunity to refine the analysis schedule where chemicals are not detected and unlikely to be present in the waste. However, this approach will also take the longest to obtain all of the sample results. Envirolab has indicated that they require 10 working days between sample receipt and the release of analysis results. Hence, the above approach would be expected to take up to 5 working weeks where 1 working week is allowed for enRiskS review at step 3. Where this timeline is not acceptable to ARRB, concurrent analysis of all 3 waste RPM for total and leachable concentrations of key chemicals, as well as SGC, is recommended. This may result in the generation of some data that is not useful for the assessment of waste disposal options or human health and environmental risks. However, results would be obtained within 2 working weeks.

3.2 Wash water

<u>General</u>

Information provided by ARRB indicates the following in relation to the wash water:

- the wash water is generated from the washing down of line marking spraying equipment and residual paint from 500 litre bladders and 20 litre buckets
- 2 types of water-based paint are used for line marking – Paint 1 and Paint 2
- the following ingredient is listed on the SDS for Paint 1:
    - ammonia (<0.2% by weight)
- the following ingredients are listed on the SDS for Paint 2:
    - acrylic polymer latex (10-30% by weight)
    - ammonium hydroxide (<0.1% by weight)
    - calcium carbonate (30-60% by weight)
    - 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate (<2% by weight)

  - titanium dioxide (1-10% by weight)
- minor amounts of an ammonia float solution is sprayed on the paint in the truck paint tank to stop the paint forming a skin
- the following ingredients are listed on the SDS for the ammonia float solution:
  - propylene glycol (10-30% by weight)
  - ammonium hydroxide (1-5% by weight)
  - water (>60% by weight).

Key chemicals of relevance

Based on the SDS for the paints used for line marking, the key chemical of relevance is ammonia. However, ammonia is volatile (as indicated on the SDS), hence, is not expected to be present at high concentrations in wash water. The other chemicals present in the paints or float solution comprise water, a polymer latex, calcium carbonate, propylene glycol, 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate and titanium dioxide. The polymer latex is the chemical that forms the paint and there are no human health or environmental risk issues of concern associated with the presence of water and calcium carbonate in wash water. Further discussion for propylene glycol, 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate and titanium dioxide is provided below.

Propylene glycol (1,2-propanediol; CAS Number: 57-55-6) is a synthetic liquid substance that absorbs water. This chemical is used in a range of applications, including to maintain moisture in certain medicines, cosmetics, or food products. It is listed as "*generally recognised as safe*" for use as an additive in food by the United States Food and Drug Administration (FDA)[3] and has been assessed to pose no unreasonable risk to human health and the environment by the Australian Industrial Chemicals Introduction Scheme (AICIS), based on its use in cosmetics and release to sewer respectively[4]. Hence, there are no human health or environmental risk issues of concern associated with the presence of propylene glycol in wash water.

2,2,4-Trimethyl-1,3-pentanediol monoisobutyrate (TMPD-MIB, texanol; CAS Number: 25265-77-4) is a volatile organic compound (VOC) found in paints and printing inks, where it is used as a coalescing agent. This chemical floats on water, has been reported in polypropylene packed food samples and may also be used to prepare carbon nanotube paste.[5,6] The AICIS has concluded that this chemical poses no unreasonable health risks based on its use in cosmetics. Hence, there are no human health risk issues of concern associated with the presence of 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate in wash water. The European Chemicals Agency (ECHA) indicates that this chemical is used in coating products, polishes and waxes, washing and cleaning products, biocides (e.g. disinfectants, pest control products), plant protection products, adhesives and sealants. It is also indicated that this chemical is readily biodegradable in freshwater and is not considered a chemical of concern for the environment.[7] Hence, there are no environmental risk issues of concern associated with the presence of 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate in wash water.

Titanium dioxide (CAS Number: 13463-67-7) is a naturally occurring oxide with a wide range of applications including in paints, fillers, adhesives, food and cosmetic/sunscreen colours.[8,9] The AICIS has concluded that this chemical poses no unreasonable risk to the environment based on its direct release to surface waters or

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[3] Propylene Glycol | Public Health Statement | ATSDR (cdc.gov)
[4] https://services.industrialchemicals.gov.au/search-assessments/
[5] 2,2,4-Trimethyl-1,3-pentanediol monoisobutyrate mixture of isomers, 99 25265-77-4 (sigmaaldrich.com)
[6] https://pubchem.ncbi.nlm.nih.gov/compound/6490
[7] Registration Dossier - ECHA (europa.eu)
[8] https://pubchem.ncbi.nlm.nih.gov/compound/26042
[9] https://www.industrialchemicals.gov.au/sites/default/files/Titanium%20dioxide_Human%20health%20tier%20II%20assessment.pdf

soil. AICIS has also assessed the potential risks to human health from this chemical, where it is indicated that titanium dioxide can be considered non-hazardous as it[10]:

- has a low water solubility and is therefore expected to have a low bioavailability for all routes of exposure
- has a low short-term (acute) oral and inhalation toxicity and is insoluble, so is not expected to sufficiently penetrate through the skin to cause system toxicity effects
- is not expected to be irrigating to the skin or eyes, or sensitising to the skin
- has been used in sunscreens at high concentrations over a long time period with no reports of skin irritation
- is not expected to cause serious damage to health following long-term (chronic) oral exposure
- is not considered carcinogenic
- is not expected to have reproductive or developmental toxicity
- may increase respiratory sensitisation to other allergens, particularly where nanoparticles are present, and serious damage to health following repeated inhalation exposure[11], however, effects may not be specific to this chemical.

Hence, there are no human health or environmental risk issues of concern associated with the presence of titanium dioxide in wash water.

In relation to other chemicals that may be present in the wash water (but not identified on the SDSs for the paints), water-based paints were reportedly developed by the paint industry to reduce the use of solvents and metals in paints, following reports of adverse health effects to painters from earlier paints. These water-based paints comprise emulsions of pigments and polymers in water, with smaller amount of solvents and additives such as biocides, surfactants, pigments, binders, amines and monomers (Wieslander, Norback & Edling 1994). The basic chemical components of paints can vary widely, depending on the required properties of the paint. The main organic solvents used in paints are toluene, xylene, aliphatic hydrocarbons, ketones, alcohols, esters and glycol ethers. Other chemicals that are listed as potentially present in water based paints are amines, ammonia, amides, formaldehyde, ethylene glycol, mercury compounds, methyl cellulose, phenols and chlorinated compounds (IARC 2012).

Based on the above, all chemicals listed in Table 4a and Table 4b of Appendix 4 of DES (2022) are identified as key chemicals for this assessment, except for:

- peroxides (item 5)
- asbestos (item 6)
- fluoride (item 26)
- polycyclic aromatic hydrocarbons (PAH) (items 6 and 42)
- dinitrotoluene (item 24)
- specific persistent organic pollutants (POPs) (items 22, 1, 33, 34, 41 and 36).

It is recommended that per-and poly-fluoroalkyl substances (PFAS) (POPs item 5) be included as key chemicals as PFAS are listed in Appendix B of the PFAS National Environmental Management Plan (NEPM) (HEPA 2020) (activities associated with PFAS contamination) in Table B2 under "*Construction industry (Tile coatings, stone coatings, paints, varnishes, sealants, other architectural coatings for films, facades and infrastructure, rigid foams, silicone rubber, thread sealant tapes and pastes and PPE)*".

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[10] https://www.industrialchemicals.gov.au/sites/default/files/Titanium%20dioxide_Human%20health%20tier%20II%20assessment.pdf

[11] Adverse health effects can be expected when this chemical is inhaled in large quantities for long periods of time, due to lung overload.

Analysis for PFAS Total Oxidisable Precursor Analysis (TOP Assay) is recommended, as per the requirements of DES (2022). i.e.

> *"As PFAS are a broad class of substances and laboratory standards are not available for every potential PFAS compound, testing must include standard analysis for easily identifiable PFAS and additional testing that shows presence/absence of other PFAS, namely the total oxidisable precursor assay (TOP assay) mentioned in the PFAS National Environmental Management Plan or an equivalently accurate detection method."*

Analysis for ammonia is recommended due to the use of the ammonia float solution.

Analysis for biological oxygen demand (BOD), chemical oxygen demand (COD) and suspended solids (SS) is recommended in case disposal to trade waste is an option.

Recommended analysis approach

The following is analysis approach is recommended for the wash water consistent with the analysis approach recommended in **Section 3.1:**

1. Provision of 3 samples of wash water to Envirolab for analysis. It is recommended that the 3 samples encompass the amount of paint that is usually present in the wash water, and the age of the wash water that requires disposal/re-use, so an indication of variability can be obtained.
2. Analysis of 1 sample of wash water, with the most paint, for the following (remaining 2 samples to be kept on hold by the laboratory):
    a) concentrations of key chemicals in Table 4a and Table 4b of Appendix 4 of DES (2022) excluding those listed above
    b) PFAS Total Oxidisable Precursor Assay (TOP Assay)
    c) Ammonia
    d) COD and SS (note, BOD is already included as it is listed in Table 4a of DES 2022)
3. Review of sample results by enRiskS to confirm that there is nothing unexpected (e.g. significantly elevated concentrations of metal/s).
4. Analysis of remaining 2 samples of wash water for:
    a) concentrations of key chemicals (as per Step 2a)
    b) PFAS TOP Assay
    c) Ammonia
    d) COD and SS.

The above approach would be expected to take up to 5 working weeks where 1 working week is allowed for enRiskS review at step 3. Where this timeline is not acceptable to ARRB, concurrent analysis of all 3 wash water samples for the key chemicals and TOP Assay. This may result in the generation of some data that is not of use for waste classification, however, results would be expected within 2 working weeks.

3.3 Uncertainties

Where chemicals from Appendices 3 and 4 of DES (2022) are not included in the recommended analysis schedule, this is because they are not expected to be present in waste RPM and wash water based on enRiskS' experience and available information (as outlined above). To support this conclusion, an additional literature search was undertaken on 11 October 2022 using Google Scholar and ScienceDirect to specifically search for literature indicating the presence of other key chemicals in waste RPM and wash water. This search did not identify any additional key chemicals for the purpose of the assessment.

It is also noted that the identification of some chemicals in the DES (2022) lists as key chemicals is conservative e.g. the inclusion of PFAS and cyanide for wash water, all metals for both waste RPM and wash water, and other petroleum hydrocarbons and phenols for waste RPM. The chemicals have been identified as key chemicals for completeness and the avoidance of doubt.

4.0 Available methods to separate solids from paint

4.1 General

In this section of the assessment a search of the online scientific literature was undertaken to source information on available methods and treatment chemicals that may assist in separating solids (including paint) from the wash water. The literature search was undertaken on 11 October 2022 using Google Scholar and ScienceDirect.

The literature search identified 3 main methods that could be used to separate solids from the wash water – membranes, coagulants and flocculants, and nanotechnology. Further discussion is provided below.

A copy of the 1 of the key papers that may be of interest to ARRB is provided in **Attachment A**. If one of the below 3 methods and/or a particular study is of interest to ARBB it may also be possible to refine the literature search determine if more specific information is available.

4.2 Nanotechnology

Nanotechnology is identified as a way of converting harmful dyes (which have a low solubility and high stability) to less harmful by-products through photocatalytic processes (Hashmi et al. 2021). Relevant nanoparticles comprise silver, gold, zinc oxide, copper oxide and titanium dioxide. While some promising results were identified using these nanoparticles, the authors also identify the potential for residual toxic effects from the nanoparticles, and that it may be difficult to scale up the technology to an industrial level.

An older review is also available outlining the use of nanoclays/organoclays (organically modified layered silicates) for waste water treatment, where the clays are used in combination with other sorbents (such as activated carbon and alum) or technologies (such as reverse osmosis) (Patel et. al. 2005). The authors note that organoclays have been proven to be superior to any other water treatment technology where the waste water contains substantial amounts of oil and grease or humic acid. In the case of oil and grease, this is effectively because organoclays comprise alternating organic (or hydrophobic) and inorganic layers, and organic substances (such as oils) can partition from water onto this hydrophobic layer.

4.3 Membranes

Membranes are used for waste water treatment in the food industry, to aid in separating substances and clean water in chemically unchanged forms, to allow recycling and/or minimise waste disposal costs (Muro, Riera & Díaz-Nava 2012). It is noted that waste water from the food industry does not normally contain toxic compounds (except where pesticides are present from washing fruits/vegetables). However, waste from this industry often has a high biological oxygen demand (BOD), chemical oxygen demand (COD) and total dissolved solids (TDS) content (due to the presence of proteins, fats, additives, dyes etc.). The authors note that:

- most commercial membranes are made of organic polymers (polysulfones and polyamides) and inorganic materials (ceramic membranes based on oxides of zirconium, titanium, silicium and aluminium)
- the 4 main membrane configurations used by the industry are plate-and-frame, spiral wound, tubular and hollow-fiber
- the choice of membrane system is usually determined by factors such as cost, risks of plugging of the membranes, packing density and cleaning opportunities

- the 4 main membrane processes used by the industry are microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO)
- the choice of membrane process is usually determined by particle size and the chemical nature of the species requiring separation.
- pre-treatments include pH adjustment, thermal treatment, addition of chemicals and pre-filtration, where:
    - pH adjustment and thermal treatment can decrease precipitation effects
    - the addition of chemicals can increase the particle size through aggregation, micellation or complexation

This paper specifically lists the NF and UF membrane processes for use in separating pigments. MF membrane processes are also identified for the removal of suspended solids.

The use of membranes for treating water and waste water is also the subject of a recent editorial (Giacobbo & Bernardes 2022), where it is identified that membrane separation processes (MSPs) have gained prominence due to their inherently low energy requirements, mild operating conditions, separation efficiency, ease of scaling up, lack of additives and the possibility of obtaining high-quality water (which can be re-used). The editorial considers the findings from 6 research articles which outline:

- the use of a cementitious microfiltration membrane (CM) with a catalytic ozone oxidation function for the removal of organic pollutants
- the combination of coagulation and ultrafiltration (UF) membrane rotation on membrane fouling control
- the effect of membrane molecular weight cut-off, transmembrane pressure, temperature and cross flow velocity for 4 different membranes used for the ultrafiltration of anaerobic digestate from swine manure
- the use of a hydrocyclone with a porous membrane wall for separating a water-oil mixture
- the effect of pH on the removal of a pharmaceutical chemical by nanofiltration with 2 commercial membranes
- the ecology and carbon footprint in a reverse osmosis sea water desalinisation plant in Spain.

4.4 Coagulants and flocculants

The use of coagulants and flocculants is identified in the scientific literature as a common and efficient method for separating paint (or other substances) from waste water. In this context and in simple terms, coagulation is the process of neutralising all the negative charges in water. This allows flocculation, which is the process where contaminants to absorb to each other. Larger particles form and settle to the bottom to be removed by sedimentation, filtration or flotation.

One study outlines the treatment of wash water from paint spray booths using chemical coagulation followed by suspended solids separation using the following (Sokolović & Sokolovic 1996):

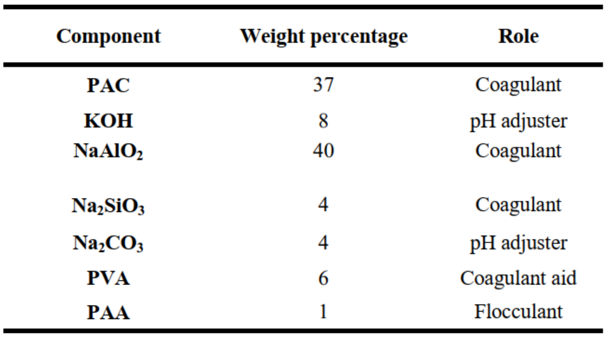
- aluminium sulphate as the coagulant (optimum dose 160 to 180 mg/L)
- polyacrylamide as the flocculant (optimum dose of 1 to 1.5 mg/L)
- domestic bauxite, perlite, zeolite and activated carbon as absorbents
- expanded polystyrene granules as packing material in the reactor and deep bed filter.

Total treatment efficiency using all processes was in the range 66 to 86%, based on COD concentrations.

Iron separation, surface charge and size are identified as important factors for coagulant-flocculant processes (Rahbar et. al. 2013). The choice of coagulant is also important as the coagulant may modify other properties of the waste water such as conductivity (Bouranene et al. 2015).

Bouranene et. al. (2015) reviews the effectiveness of iron based coagulants (ferrous sulphate, ferric sulphate and ferric chloride) on the treatment of waste water from the preparation of water based paints (blanroc super[12]). The effect of pH was also investigated. The authors found that pH played a significant role in the coagulation-flocculation process. Treatment was most effective when the pH was adjusted to 2.5 units before adding the coagulant, and then a base was added to increase the pH to 7 to 8 units. Treatment efficiency varied depending on the coagulant used and the blanroc super concentration.

The effect of pH on coagulation and flocculation processes in paint waste water was also investigated by Rahbar et. al. (2013), where a pH range of 9.5 to 10.5 units was found to be most effective i.e. maximum paint removal, of up to 95%, was obtained in this pH range. This was due to the increase in aluminium hydroxide ions and solid content removal with increasing pH. The composition of the flocculant-coagulant compound used in this study is shown in **Exhibit 4.1**. A copy of Rahbar et. al. (2013), with the full details of the experimental methodology, is provided in **Attachment A**.



Component	Weight percentage	Role
PAC	37	Coagulant
KOH	8	pH adjuster
$NaAlO_2$	40	Coagulant
Na_2SiO_3	4	Coagulant
Na_2CO_3	4	pH adjuster
PVA	6	Coagulant aid
PAA	1	Flocculant

Exhibit 4.1. Composition of flocculant-coagulant compound investigated by Rahbar et. al. (2013).

Other studies (Aboulhassan et. al. 2014; da Silva et al. 2016; Kulkarni 2017) note that while coagulation-flocculation processes are widely used and simple to operate, overall performance may still be poor and further treatment may be required to reduce colour, organic loading and odour.

Aboulhassan et. al. (2014) pre-treated waste water from paint manufacturing with the flocculant ion chloride and the anionic polyelectrolyte Chemic 5161. Batch aerobic biological treatment was then undertaken in an aeration tank (a 2 litre tank with a magnetic stirrer and aeration via pumps and diffusers). An activated sludge culture was obtained from a municipal biological waste water treatment plant and cultivated in diluted waste water prior to addition to the aeration tank. This resulted in the generation of a clear effluent with 97% colour removal. The removal efficiency for COD and BOD was 96% and 92.5% respectively.

da Silva et. al. (2016) investigated the treatment of waste water from water based acrylic paint manufacturing using the coagulant aluminium sulfate with electrochemical methods (boron-doped diamond [BDD] electrode). Electrochemical methods transform organic compounds into biodegradable substances which are eventually converted to carbon dioxide and water. The authors found that while the use of aluminium sulfate alone (at a dosage of 12 mL/L) was effective at treating the waste water, the use of electrochemistry was required to treat the water to the standard required for discharge into water bodies.

4.5 Other methods

Kulkarni (2017) identifies the following additional methods for the treatment of waste water from the paint industry (either alone or in combination with other methods):

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[12] Blanroc super is a white substance in emulsion form that is used to form paint, comprising 12% by weight polyvinyl acetate (PVA), 45.5% by weight calcium carbonate, 4% by weight titanium dioxide and 35.5% by weight water.

- advanced oxidation using Fenton reagents and hydrogen peroxide
- cactus enzymatic system and cactus biopolymer sludge treatment
- photochemical
- ion exchange
- radiation.

The use of lignin for the treatment of waste water containing heavy metal ions, inorganic anions, organic dyes and drugs has also been reviewed (Wang et al. 2022). Lignin a naturally synthesised polymer found in plant cell walls that has potential applications as a readily available and low cost absorbent.

5.0 Industrial versus architectural/decorative paint

A search of publicly available online information as part of this assessment did not identify any clear reasons why regulated waste in Queensland (and in other states such as Victoria) includes industrial paint but not architectural/decorative paint. Possible reasons include:

- industrial paints may be produced and/or used in larger volumes
- industrial paints may contain different chemicals to architectural/decorative paints (e.g. metals or higher concentrations of solvents) as they are developed for specialist applications
- industrial paints may be used with other additives.

It is also noted that Australia has a program called Paintback which is industry-led and has been operational in Australia since 2016. This program provides a way for the general public (households) to easily dispose of up to 100 litres in volume (per visit) of architectural/decorative paint and packaging. It is funded through a levy of 15 cents (plus GST) per litre applied to the wholesale price of eligible products. This funding is used for research and development activities that aim to improve resource recovery and divert waste paint away from landfill. Aerosol paints, industrial surface and maintenance coatings and additives are not accepted by Paintback.

One way to compare the difference between architectural/decorative and industrial paints is to compare the information on the SDS for an example of both paint types from the same supplier. SDS for an architectural/decorative (interior) paint and an industrial (line marking) paint from the same Australian supplier were reviewed as part of this assessment. Both SDS are marked “Non-Hazardous Chemical” and “Non-Dangerous Goods”, and 100% of the listed ingredients for both products are determined to be non-hazardous. The listed measures for first aid, firefighting, accidental release, handling and storage and exposure controls/personal protection are identical between both SDS. Similarly, there are no differences in the listed information for stability and reactivity, toxicology, ecology, disposal and transport. The line marking paint is listed as having a mild ammonia odour and the odour of the interior paint is listed as “mild characteristic”.

Paintback describes paint as a “high volume low toxicity product”. Based on the above SDS, both the interior paint and the line marking paint are low toxicity products.

To confirm whether there are any significant differences in the chemicals and concentrations in interior paint as compared to line marking paint, the recommended analysis approach outlined in **Section 3.2** could be applied to both paints. There are many paints that could be selected for this analysis and the selection of 2 different water-based interior paints is recommended to provide an idea of variability. Line marking paints selected for investigation should have similar ingredients to those of Paint 1 and Paint 2 that were investigated as part of this review.

6.0 Conclusions

This review has identified the key chemicals in waste RPM and wash as relevant to waste disposal and beneficial re-use of these materials. The identified key chemicals are outlined in **Section 3.1** (waste RPM) and **Section 3.2** (wash water), along with a recommended analysis approach.

There are 3 main methods that could be used to separate solids from the wash water – the use of membranes, coagulants and flocculants, and nanotechnology. A copy of the one of the key papers that may be of interest to ARRB is provided in **Attachment A**. If one of the above 3 methods and/or a particular study is of interest to ARBB it may also be possible to refine the literature search determine if more specific information is available.

In relation to the differences between architectural/decorative and industrial paint, this review has not identified any clear reasons why regulated waste in Queensland (and in other states such as Victoria) includes industrial paint but not architectural/decorative paint. Possible reasons include:

- industrial paints may be produced and/or used in larger volumes
- industrial paints may contain different chemicals to architectural/decorative paints (e.g. metals or higher concentrations of solvents) as they are developed for specialist applications
- industrial paints may be used with other additives.

It is also noted that Australia has a program called Paintback which is industry-led and has been operational in Australia since 2016. Aerosol paints, industrial surface and maintenance coatings and additives are not accepted by Paintback.

To confirm whether there are any significant differences in the chemicals and concentrations in architectural/decorative paint as compared to line marking paint, the analysis approach outlined in **Section 3.2** could be applied to architectural/decorative paint and industrial paint manufactured by the same supplier. The analysis of 2 different water-based architectural/decorative paints is recommended (there are many paints that could be selected for this analysis). Line marking paints selected for investigation should have similar ingredients to those of Paint 1 and Paint 2 that were investigated as part of this review.

7.0 Limitations

Environmental Risk Sciences Pty Ltd has prepared this report for the use of ARRB and TMR in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in this report.

The methodology adopted and sources of information used are outlined in this report. Environmental Risk Sciences Pty Ltd has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

This report was prepared in October 2022, and updated in September 2023, and is based on the information provided and reviewed at that time. Environmental Risk Sciences Pty Ltd disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Yours sincerely,

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کارگاه آموزشی
آموزش نرم افزار Word برای پژوهشگران


کارگاه آموزشی
روش تحقیق کمی


کارگاه آموزشی
آموزش مهارت های کاربردی در تدوین و چاپ مقالات ISI

Journal of Chemical Health Risks

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ORIGINAL ARTICLE

Effect of pH on Separation of Solid Content from Paint Contained Wastewater by a Coagulant-flocculant Compound

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KEYWORDS

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Flocculent
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ABSTRACT: Chemical wastewater treatment is one of the attracting and common methods for wastewater treatment among the currently employed chemical unit processes. The use of coagulant-flocculant compound is one of the efficient methods for separating of paint and recovery of water. In this research, it was introduced and the effect of pH on removal of solid content from solution was studied experimentally. For this purpose, sludge and suspended solid content of the solution were determined in a jar test by measurement of UV absorption of treated solution and solid separation percentage. The results showed that in pH range 9.5-10.5, maximum efficiency of solid content removal was up to 95%. Consequently, maximum paint removal was obtained in this range of pH. The separation of solid content of the solution was due to formation of aluminum hydroxide. As shown by the results, the reduction of potassium hydroxide as pH adjuster caused decrease of pH and consequently decrease of aluminum hydroxide and solid content removal.

INTRODUCTION

In chemical industries, organic compounds are the most pollutants of effluent in water. The basis of water treatment process is separating solid-liquid phase. This process accomplish with chemical materials and special equipments. The high purity water can be achieved by this type of process and it can reuse in various industries. Flocculants and coagulants are used in suspending and coagulating process for separating of solid phase which exists as a suspension in a liquid. For ion separation, size and surface charge are two significant factors which play a vital role in coagulation-flocculation processes [1]. Coagulation is a process which neutralizes all negative charges of water and accordingly contaminations absorb each other. The use of polymeric Aluminum compound as a flocculant agent is more common these days. Poly Aluminum Chloride

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(PAC) and Poly Aluminum Phosphate are two clear-cut examples of mentioned compound.

Note that PAC application is more popular than other compounds. These kinds of coagulants efficiently act in a low temperature and wide range of pH. Polymeric coagulants usually have high charge density and chain length. They can surround the color by their metallic elements like Aluminum, Iron and Silicon. Through this process, the color is neutralized and removed [2, 3].

Aluminum sulphate is an example of flocculants that could bond with Sodium Hydrogen Carbonate or Potassium Hydroxide and they are formed insoluble metallic Hydroxides such as Aluminum Hydroxide and Iron Hydroxide. Generally, Hydroxides which are water-insoluble have such a low solubility and cause of polymeric and viscous form of water [4].

The coagulation of colloidal ions were examined in solutions which contain Humic acid/Aluminum sulphate solution at pH in range 4-10 and Aluminum sulphate (3-1000 µM Al). They studied the effects of colloidal ions with analyzing colloid surface change and UV absorbance of solution. The obtained results showed the appropriate performance range of coagulation (pH solution and quantity of Al) and the mechanism of coagulation [5].

In an *invitro* study, the effects of three organic coagulants were presented on decrease of discharge effluent turbidity in an industrial unitare. These coagulants consist of Aluminum sulphate, Ferric chloride II and Poly Aluminum chloride which optimum dosage and pH of each ones are determined. In the case of applying 20 mg/L of PAC at pH=6, optimum efficiency of decreasing wastewater turbidity are reached, although the maximum turbidity decrease up to 90% could be achieved by applying 50 mg/L of PAC at pH=6 [6].

The effects of pH, Aluminum and Iron concentration were studied on color removal from effluentsare. They presented the effects of those factors on amount of sedimentation in different Aluminum Hydroxide Compounds which form in accordance with correspondent reactions [7].

In an *in vitro* investigation, a novel formulation of Poly Aluminum chloride and Potassium hydroxide along with other materials as pH adjuster and coagulant aid was introduced which increases the amounts of solid content removal to 96% [8].

The Polymeric chloride – Poly-epichlorohydrin-dimethylamine (PFC-ECH-DAM) composite flocculants with different OH/Fe ratios, Fe to organic ECH-DAM mass ratios and cross-linker types were comparatively investigated in terms of formed floc aggregation process and floc characteristics for the treatment of synthetic dyeing wastewater. The results demonstrated that the synergic effect of PFC with ECH-DAM promoted the formation of larger flocs with higher growth rate and wider distribution of floc sizes. During the coagulation of reactive red (K-2BP) dyeing wastewater, strengthened floc properties can be obtained at higher flocculant dosage ranges (>80 mg/L) and solution pH of about 7.5 [9].

Five novel coagulants, DC-491, Fennofix K97, BWD-01, MD-03 and MD-04 were chosen to treat reactive brilliant red X-3B simulated wastewater by jar tests. The results showed that the decolorization efficiencies were all higher than 75% at initial pH 8.2 and temperature 20 after 20 minutes of reaction. Then, two typical coagulants, BWD-01 and MD-04 which had better performance were chosen to study the effect of dye removal of X-3B at different operating parameters, including coagulant dosage, pH, and sedimentation time and reaction temperature of simulated wastewater. Decolorization efficiency of MD-04 for X-3B solution was higher than 80% in pH range from 3 to 9, while for

BWD-01, efficiency increased from 37.3% to 82.3% in this pH range [10].

Several options of decolorization of textile wastewater by chemical means have been reviewed. Based on this review, some novel pre-hydrolyzed coagulants such as Polyaluminium chloride (PACl), Polyaluminium ferric chloride (PAFCl), Polyferrous sulphate (PFS) and Polyferric chloride (PFCl) have been found to be more effective and suggested for decolorization of the textile wastewater. Moreover, use of natural coagulants for textile wastewater treatment has also been emphasized and encouraged as the viable alternative because of their eco-friendly nature [11].

The coagulation–flocculation treatment using $FeSO_4 \cdot 7H_2O$ as a coagulant was evaluated for the removal of organic compounds and color from synthetic effluents simulating the cotton, acrylic and polyester dyeing wastewaters. The obtained results showed that the optimal operating conditions were different for each effluent, and the process (coagulation–flocculation) as a whole was efficient in terms of color removal (~91% for cotton, ~94% for acrylic effluents; polyester effluent is practically colorless) [12].

The coagulation–flocculation process was studied to find out the performance of different coagulants and flocculants like alum, ferric chloride, Aluminium chloride, ferrous sulphate, poly Aluminium chloride (PAC), cationic and anionic Polyacrylamide polymers in individual form as well as in different combinations. The effects of dosing rate, settling time and pH were examined for reduction of COD, TSS and color. Coagulants used in combinations were found to be more effective in reducing COD, TSS and color instead of using individual form. The initial pH of the effluent for coagulation process was found to have remarkable effect on COD, TSS and color removal. The most effective results were found using cationic and anionic Polyacrylamide combination with ferric chloride and Aluminium chloride and reduction of 76% COD, 95% TSS and 95% color were observed at pH < 3 [13].

In this investigation, the effects of pH solution were experimentally examined on performance of color removal by coagulation–flocculationprocess. For this purpose, a new coagulant-flocculant compound was applied in the form of solid powder [14].

MATERIALS AND METHODS

Materials

*The Sample***:** For preparing the sample, a kind of alkyd paint (vehicle color paint-Hadi’s brand) was dissolved in water such a way that the concentration of color in water equals 5gr/L. This concentration of color was chosen according to presented information by PPG (Italy) and BASF (Germany) companies about concentration of colors in effluent of automotive factories [15, 16].

Flocculant-Coagulant Materials

The new flocculant-coagulant compoundis were used to investigate the role of pH. This powdery substance contained the following composition that each of them played a role in the flocculation-coagulation process. The role of each component in flocculant-coagulant composition shows in Table 1.

Table 1. Composition of flocculant-coagulant powder [8]

Component	Weight percentage	Role
PAC	37	Coagulant
KOH	8	pH adjuster
$NaAlO_2$	40	Coagulant
Na_2SiO_3	4	Coagulant
Na_2CO_3	4	pH adjuster
PVA	6	Coagulant aid
PAA	1	Flocculant

Experimental

A mixer model RW20-n fabricated by IKA company was used for mixing coagulant-flocculant powder of sample. Its characteristics are listed in Table 2.

Table 2. Specifications of the mixer

Impeller Type	No. of Impeller	Impeller Dia.(mm)	Shaft Length(mm)	Shaft Dia.(mm)	Max. Speed(rpm)
Propeller	4	50	350	8	2000

UV Spectrophotometer model Ikon was supplied by Biotek-Kontron company which has one Tungsten lamp (for visible light) and one Deuterium lamp (for UV ray) was applied to determine the UV absorption. pH meter model RL-150 made by Russel company(England) was used to determine the quantity of solution pH.

Experimental procedure

A jar test was performed as one liter of the sample was poured into the mixer and mixed with 400 rpm speed. One gram of coagulant-flocculant powder was added during the mixing and mixing was continued within 1.5 minutes upon coagulating phenomena was completed. Then, mixing was implemented with 200 rpm speed within 15 minutes in order to flocculate the paint. For floating flocculated paint on the water, the solution was released within 2 hours. The paint which was turned into sludge was removed by filter Paper. pH of solution was changed by changing the quantity of Potassium Hydroxide. The operation was carried out in ambient temperature. The condition of the performed test shows in Table 3.

Table 3. The condition of the performed test

Coagulation Time(sec)	Coagulation Speed(rpm)	Focculation Time(sec)	Flocculation Speed(rpm)	Settling Time(hr)	Solution pH
90	400	900	200	2	8.5-10

Method of estimation of solid content removal

Presented method by PPG (Italy) and BASF (Germany) was applied to calculate the amount of solid content removal (paint plus coagulant-flocculant compound) which are suspended as a sludge in the solution such a way that sludge was separated from solution by paper filter[14, 15]. Then, the sludge was put on a watch glass and placed in oven with 105^{o}C within 2 hours until water was taken. If (a) shows the amount of remained solid after separation of water from the sludge and (b) shows the amount of coagulation-flocculation compound which was used, then color separation percentage was obtained by following equation. It should be noted that total amount of solid in the solution is flocculant-coagulant powder plus dissolved paint.

(I) ***a*** = Weight of solid content in the dry sludge (removed paintand coagulant-flocculant powder)

(II) ***b*** **=** Weight of remained (suspended) solid in the solution after coagulation-flocculation treatment

(III) ***c*****=** Initial total weight of solid in the solution **=** ***a*** **+** ***b***

(IV) Separation percentage of solid content $=(\frac{a}{c})\times 100$

(V) Suspended solid content percentage

$$= \left(\frac{b}{c}\right) \times 100$$

RESULTS AND DISCUSSION

The variation of removed solid versus pH of solution is demonstrated in Figure (1). As it can be seen, due to increase of pH and alkalinity of solution, the amount of removed solid has been increased. Also, the most amount of solid has been separated when pH varied in range of 9.5-10.5. According to equation **IV** and considering that ***c*** is constant, increase of ***a*** (parameter of equation **I**) decreased band solution has the minimum amount of suspended solid when pH was in this range, as shown in Figure (2). Solid removal percentages in different pH are presented in Figure (3) which shows that maximum separation was achieved when pH varied in range of 9.5-10.5. Also, the results showed that in this range of pH, the minimum amount of solid spills existed in the remained solution and consequently, the minimum UV absorption of solution was obtained (Figure 4). For describing the phenomena, it should be mentioned that, the main coagulant agents in coagulant-flocculant composition contains *Al* ions, that surround color powder and neutralize them as it is illustrated in Figures (5) and (6). Furthermore, the alkaline pH of the solution, between 9.5-10.5, caused to release enough amount of OHions in solution which increased the intensity of reaction in order to produce aluminum hydroxide and consequently, to increase coagulation of paint ions and separating them. If pH of solution was decreased lower than the mentioned range (by decreasing potassium hydroxide which controls pH value), the intensity of reaction for production of aluminum hydroxide would decrease and, as a result, the required coagulating of solution for paint removal did not occur and this phenomena led to reduce the rate of paint removal. If pH solution increased more than 10.5, the extra amount of OH ions would remain in solution which caused the following reaction improved on the contrary way and reduced the quantity of Al ions thus lower amount of paint ions was coagulated in solution.

CONCLUSION

In this study, effects of pH on removal of solid content from painted wastewater were examined with a novel coagulant-flocculant composition. Experimental results showed that, as pH solution was closer to 10.5 and solution was more alkaline, amount of OH ions increased and coagulation of paint ions were improved. The increase of coagulation of paint ions caused increase of solid separation in sludge form and therefore, amount of suspended solid were reduced in the solution. Moreover, decrease of solution alkalinity (by decreasing of amount of potassium hydroxide formation) led to form the lower amount of Al $(OH)_3$ and consequently, coagulation and solid removal were decreased.

$$Al(OH)_3 \rightleftarrows Al^{3+} + 3OH^-$$

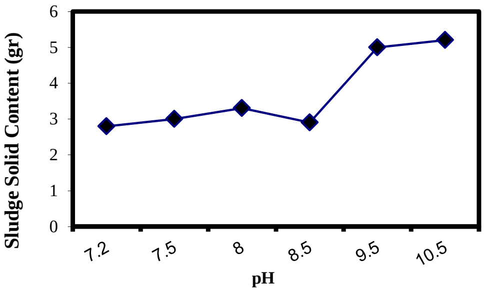

Figure1. Variation of separated solid as sludge in different pH

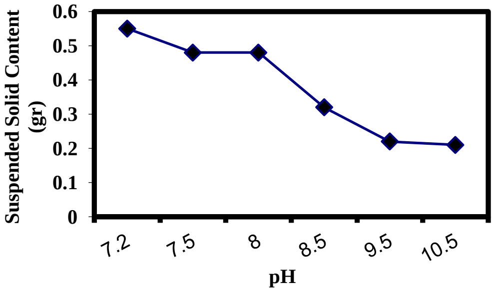

Figure 2. Variation of remaining suspended solid in solution in differentpH

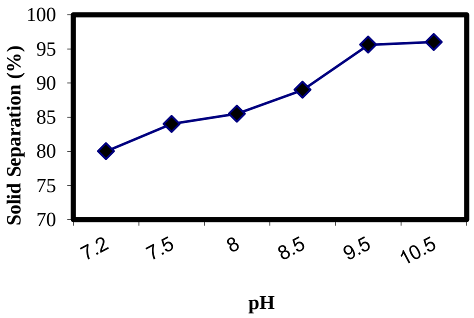

Figure 3. Variation of color solid separation percentage in different pH

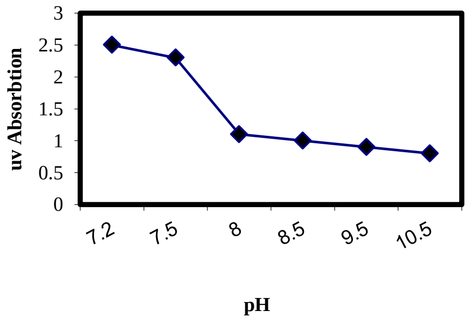

Figure 4. The absorption of solution after solid separation in different pH

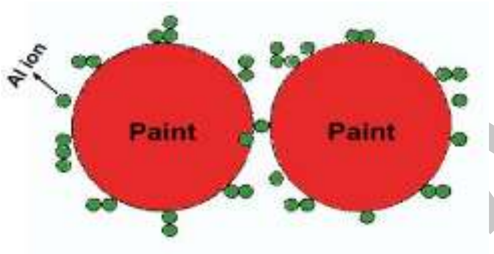

Figure 5: Illustration of surrounding paint ions by *Al* ions

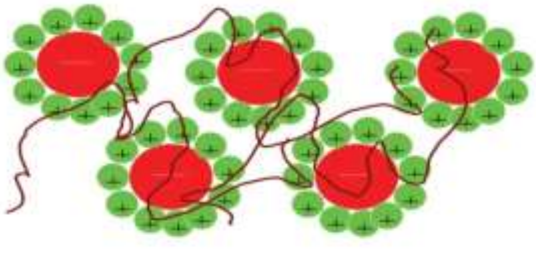

Figure 6. Coagulating-Flocculation phenomena on paint particles (ions)bypresence of the coagulant-flocculant powder in paint contained waste water

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Technical review: Raised Pavement Markers (RPM) and paint wash water

Prepared for: Australian Road Research Boards (ARRB) and the Queensland Department of Transport and Main Roads (TMR)

18 September 2023

Document History and Status

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Limitations

Environmental Risk Sciences has prepared this report for the use of the Australian Road Research Board (ARRB), on behalf of the Queensland Department of Transport and Main Roads (TMR), in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in the Section 1 of this report.

The methodology adopted, and sources of information used are outlined in this report. Environmental Risk Sciences has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

This report was prepared in February-March 2023, and updated in April and September 2023, and is based on the information provided and reviewed at these times. Environmental Risk Sciences disclaims responsibility for any changes that may have occurred after this time.

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Table of Contents

Appendices

Glossary of Terms

ADWG	Australian Drinking Water Guidelines
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ASC NEPM	National Environment Protection Measure (Assessment of Site Contamination)
ASLP	Australian Standards Leaching Procedure
BOD	Biological Oxygen Demand
COA	Certificate of Analysis
COD	Chemical Oxygen Demand
CoPC	Chemical of Potential Concern
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
DES	Queensland Government Department of Environment and Science
EC	Electrical Conductivity
EIL	Ecological Investigation Level
EV	Environmental Value
HIL	Health Investigation Level
HHERA	Human Health and Ecological Risk Assessment
HSL	Health Screening Level
LOR	Limit of Reporting
MAH	Monocyclic Aromatic Hydrocarbons
MOS	Margin of Safety
NEPC	National Environment Protection Council
OHS	Occupational Health and Safety
PAH	Polycyclic Aromatic Hydrocarbons
PFAS:	Per- and Polyfluoroalkyl Substances
PFOS	*Perfluorooctane sulfonate*
PFBA	*Perfluorobutanoic acid*
PFPeA	*Perfluoropentanoic acid*
PFHxA	*Perfluorohexanoic acid*
PFHpA	*Perfluoroheptanoic acid*
PFOA	*Perfluorooctanoate*
PFHxS	*Perfluorohexane sulfonate*
PPE	Personal Protective Equipment
RAP	Reclaimed Asphalt Pavement
RPM	Raised Pavement Marker
RSL	Regional Screening Level
SGC	Silica Gel Clean-Up
TOP	Total Oxidisable Precursor
TRH	Total Recoverable Hydrocarbons
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WHO	World Health Organisation
WQO	Water Quality Objective

Section 1. Introduction

1.1 Background

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by the Australian Road Research Board (ARRB), on behalf of the Queensland Department of Transport and Main Roads (TMR), to undertake a technical review and provide advice in relation to disposal and/or beneficial re-use of:

- waste created during the removal of raised pavement markers from roads (waste RPM)
- wash water derived from the use of water-based line marking paint (wash water).

Both materials are currently disposed as regulated waste in Queensland. Waste RPM are disposed of as Category 1 regulated waste under default waste categorisation item 59 - *tarry residues arising from refining, distillation or any other pyrolytic treatment* (DES 2022a). Item 59 has been selected by ARRB as a bitumen adhesive is used to affix the RPM to the road, and a small amount of the adhesive as well as residual bitumen is unable to be removed from the waste RPM. Wash water is disposed of as Category 2 regulated waste under default waste categorisation item 70 - *waste from the manufacture, formulation or use of inks, dyes, pigments, paints, lacquers or varnish* (DES 2022a).

Exhibit 1.1 shows photographs relevant to the wastes being reviewed.

Exhibit 1.1. Photographs (provided by ARRB) of wastes being reviewed in this letter comprising 1) waste generated following RPM removal, and 2) typical wash bay where line marking equipment is washed into a sump and pumped to holding tank for disposal.

1.2 Objectives

The objectives of the technical review presented in this report are to:

- re-categorise (where appropriate) waste RPM and wash water for disposal
- undertaken a human health and ecological risk assessment (HHERA) for the beneficial re-use of waste RPM for the following applications:

- Application 1 – partial aggregate replacement in asphalt
- Application 2 – use in materials underlying asphalt (entombing the waste RPM, where a new asphalt road is laid over an older asphalt road with RPMs affixed).

This review has addressed waste disposal and human health and ecological risk issues relevant to the disposal and/or re-use of the wastes based on information provided to 24 February 2023, and as described in this report. The review has not addressed any other waste materials or human health and environmental risks associated the generation of the waste products or other beneficial re-use scenarios. This review does not replace the environmental and/or occupational health and safety (OHS) procedures that are required for generation, handling and/or disposal of the wastes.

1.3 Approach and scope of works

The review has been undertaken in accordance with the following regulations and guidelines:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)
- Department of Environment and Science (DES), Information sheet, Regulated waste, Overview of regulated waste categorisation, Queensland Department of Environment and Science, ESR/2019/4749, Version 3.01, Effective: 14 APR 2022 (DES 2022a)
- DES, March 2022 Guideline on Environmental Protection (Water and Wetland Biodiversity) Policy 2019, Deciding aquatic ecosystem indicators and, local water quality guideline values (DES 2022b)
- enHealth (enHealth 2012) Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards
- National Environmental Protection Measure – Assessment of Site Contamination (ASC NEPM) including:
    - Schedule B1 Investigation Levels for Soil and Groundwater (NEPC 1999 amended 2013a)
    - Schedule B4 Guideline on Site-Specific Health Risk Assessment Methodology (NEPC 1999 amended 2013b)
    - Schedule B5 Guideline on Ecological Risk Assessment (NEPC 1999 amended 2013c)
    - Schedule B7 Guideline on Derivation of Health-Based Investigation Levels (NEPC 1999 amended 2013d)
    - Toolbox Note – Key principles for the remediation and management of contaminated sites
- Queensland Government, Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (DES 2019).

Where required, additional guidance has been obtained from relevant Australian and International sources such as that available from the United States Environmental Protection Agency (USEPA) and the World Health Organisation (WHO) consistent with current industry best practice.

The overall approach adopted in this assessment is as follows:

- review of waste categorisation for waste RPM and wash water (**Section 2**)
- screening level HHERA for the beneficial re-use of waste RPM (**Section 3**)
- review of end of waste (EOW) considerations for waste RPM (**Section 4**)
- conclusions (**Section 5**) and recommendations (**Section 6**).

Section 2. Waste categorisation

2.1 General

In October 2022, enRiskS completed an interim technical review to determine the key chemicals of relevance to the waste RPM and wash water for disposal or beneficial re-use. The purpose of the interim technical review was to determine the data that was needed for this review. The interim technical review was revised to remove product branding in September 2023. A copy of the interim technical review is provided in **Appendix A**.

Sample of waste RPM and wash water were subsequently submitted to Envirolab for analysis for the key chemicals identified during the conduct of the enRiskS interim technical review. The data obtained through this analysis is presented in **Appendix B** and forms the basis for this review.

Information provided by ARRB and TMR (as referenced in this report) has also been relied upon for this review.

2.2 Waste RPM

2.2.1 Key chemicals of relevance

Table 2.1 summarises the key chemicals of relevance for waste RPM from and the recommended analysis for each key chemical as per the enRiskS interim technical review. A copy of the enRiskS interim technical review with the justification of key chemicals is provided in **Appendix A**.

Table 2.1: Key chemicals of relevance – waste RPM (in order of priority) (refer to Appendix A)

Attribute or substance (item number from Appendix 3 of DES 2022a)	Rationale	Analysis type	
		Total concentrations	Leachable concentrations (ASLP at neutral pH)
Petroleum hydrocarbons			
Petroleum hydrocarbons (C10 to C36) (38)	Main chemical in bitumen	✓	--
Silica gel clean-up (NA)		✓	--
Polycyclic aromatic hydrocarbons			
Benzo(a)pyrene (6)	Main chemical in bitumen	✓	✓
Polycyclic aromatic hydrocarbons (total) (42) [1]		✓	--
Petroleum hydrocarbons			
Petroleum hydrocarbons (C6 to C9) (37)	Bitumen contains other petroleum hydrocarbons	✓	--
Monocyclic aromatic hydrocarbons			
Benzene (5)	Bitumen contains other petroleum hydrocarbons	✓	✓
Toluene (54)		✓	✓
Ethylbenzene (25)		✓	✓
Xylenes (total) (57)		✓	✓
Styrene (vinyl benzene) (44)		✓	✓
Phenols			
Trichlorophenol (2,4,5-trichlorophenol) (52)	Bitumen may contain phenols	✓	✓
Trichlorophenol (2,4,6-trichlorophenol) (53)		✓	✓
Cresol (total) (15)		✓	✓
Phenols (total) (40)		✓	✓
Inorganic species			
Antimony (2)	Bitumen may contain metals	✓	✓
Arsenic (3)		✓	✓
Barium (4)		✓	✓

Attribute or substance (item number from Appendix 3 of DES 2022a)	Rationale	Analysis type	
		Total concentrations	Leachable concentrations (ASLP at neutral pH)
Beryllium (7)		✓	✓
Boron (8)	Bitumen may contain metals	✓	✓
Cadmium (9)		✓	✓
Chromium (hexavalent) (13)		✓	✓
Copper (14)		✓	✓
Lead (27)		✓	✓
Mercury (28)		✓	✓
Molybdenum (30)		✓	✓
Nickel (31)		✓	✓
Selenium (43)		✓	✓
Silver (45)		✓	✓
Vanadium (55)		✓	✓
Zinc (58)		✓	✓
Other			
pH (1)	Recommended for re-use assessment	✓	--

Notes:

"✓"	= indicates analysis recommended.
"--"	= indicates analysis not recommended.
NA	= indicates not applicable.
1	= sum of acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenzo(ah)anthracene, fluoranthene, fluorene, indeno(a,2,3-cd)pyrene, naphthalene, phenathrene and pyrene.

2.2.2 Available data

Following consultation with ARRB and TMR, the enRiskS interim technical review recommended the analysis of 3x 1 kg samples of waste RPM (approximately 10x individual RPM) from 3 different areas of Queensland (Rockhampton, the Gold Coast and Toowoomba).

These samples were subsequently provided to Envirolab for analysis for total concentrations of key chemicals of relevance (as per **Table 2.1**). Photographs of the samples provided to Envirolab are shown on **Exhibit 2.1**. Unfortunately, Envirolab advised that it was not feasible to crush the 1 kg samples for laboratory analysis as the RPM were too hard (noting that RPM are designed to be driven over by vehicles). Methods trialled by Envirolab for crushing including use of a hammer/tomahawk and chipper.

It was subsequently agreed between enRiskS, Envirolab, ARRB and TMR that Envirolab would choose 2 representative waste RPM from each 1 kg sample of waste RPM, break the waste RPM down as far as possible, and ensure that each part of the waste RPM (i.e. reflector, backing and bitumen) was included for sample extraction. Liquid nitrogen was also trialled and subsequently used to assist with breaking down the waste RPM.

The waste RPM from Rockhampton were analysed first, as these RPM was assessed to be the most variable (refer to **Exhibit 2.1**).

Exhibit 2.1. Photographs (provided by Envirolab) of waste RPM samples provided for analysis (from left to right: Rockhampton, Gold Coast and Toowoomba).

Following the receipt of the results for total concentrations of key chemicals of relevance in the Rockhampton waste RPM in November 2022, analysis of total concentrations of key chemicals of relevance in waste RPM from the Gold Coast and Toowoomba was requested. In January 2023, leachability testing (Australian Standards Leaching Procedure; ASLP, at neutral pH) was requested for all 3 waste RPM samples and the following chemicals which were detected in waste RPM:

- toluene, ethylbenzene, styrene
- naphthalene
- phenol
- copper
- vanadium
- total recoverable hydrocarbons (TRH).

Note that leachability analysis for TRH was not originally recommended as an outcome of the enRiskS interim technical review (ASLP TRH is not included in **Table 2.1**). However, ASLP TRH was subsequently requested as TRH were the main chemicals detected in the waste RPM and DES (2022a) provides categorisation thresholds for total petroleum hydrocarbons (TPH) in liquid wastes. TRH >C10 analysis was also repeated for the purpose of silica gel clean-up (SGC) analysis.

The available data is provided in **Appendix B** and summarised in **Table 2.2**.

Table 2.2: Summary of concentrations of key chemicals of relevance in waste RPM

Contaminant	**Reported concentration [1]**					
	Rockhampton		**Gold Coast**		**Toowoomba**	
	Total concentration (mg/kg)	**Leachable concentration, neutral pH (mg/L)**	**Total concentration (mg/kg)**	**Leachable concentration, neutral pH (mg/L)**	**Total concentration (mg/kg)**	**Leachable concentration, neutral pH (mg/L)**
Petroleum hydrocarbons (Total Recoverable Hydrocarbons; TRH)						
TRH C6-C9	26	<0.01	<25	<0.01	68	<0.01
TRH C6-C10	67	<0.01	<25	<0.01	80	<0.01
TRH C6-C10 minus BTEX (F1)	61	<0.01	<25	<0.01	77	<0.01
TRH C10-C14	500	--	<500	--	1,200	--
TRH C10-C14	<500 [2]	<0.05	<500	<0.05	<500 [2]	<0.05
TRH C10-C14 SGC	<500 [2]	--	<500	--	<500 [2]	--
TRH C15-C28	5,900	--	4,800 – 5,700 *	--	2,700	--
TRH C15-C28	1,600 [2]	<0.1	4,800 [2]	<0.1	3,800 [2]	<0.1
TRH C15-C28 SGC	1,700 [2]	--	4,300 [2]	--	2,000 [2]	--
TRH C29-C36	1,400	--	8,600 – 9,200 *	--	1,200	--
TRH C29-C36	3,300 [2]	<0.1	9,700 [2]	<0.1	1,900 [2]	<0.1
TRH C29-C36 SGC	3,500 [2]	--	8,500 [2]	--	1,800 [2]	--
TRH C10-C36	7,800	--	13,000 – 15,000 *	--	5,100	--
TRH C10-C36	4,900 [2]	--	14,000 [2]	--	5,700 [2]	--
TRH >C10-C16	700	--	<500	--	1,300	--
TRH >C10-C16 minus naphthalene (F2)	700	--	<500	--	1,300	--
TRH >C10-C16	<500 [2]	<0.05	<500 [2]	<0.05	<500 [2]	<0.05
TRH >C10-C16 SGC	<500 [2]	--	<500 [2]	--	<500 [2]	--
TRH >C16-C34 (F3)	6,600	--	11,000 – 13,000 *	--	3,300	--
TRH >C16-C34 (F3)	3,700 [2]	<0.1	12,000 [2]	<0.1	4,200 [2]	<0.1
TRH >C16-C34 (F3) SGC	3,900 [2]	--	10,000 [2]	--	3,000 [2]	--

Contaminant	**Reported concentration [1]**					
	Rockhampton		**Gold Coast**		**Toowoomba**	
	Total concentration (mg/kg)	**Leachable concentration, neutral pH (mg/L)**	**Total concentration (mg/kg)**	**Leachable concentration, neutral pH (mg/L)**	**Total concentration (mg/kg)**	**Leachable concentration, neutral pH (mg/L)**
TRH >C34-C40 (F4)	1,500	--	7,700	--	1,400	--
TRH >C34-C40 (F4)	4,400 [2]	<0.1	7,800 [2]	<0.1	2,500 [2]	<0.1
TRH >C34-C40 (F4) SGC	4,500 [2]	--	6,600 [2]	--	2,500 [2]	--
TRH >C10-C40	8,800	--	19,000 – 20,000 *	--	6,000	--
TRH >C10-C40	8,100 [2]	--	20,000 [2]	--	6,700 [2]	--
Monocyclic aromatic hydrocarbons (MAH)						
Benzene	<0.2	<0.001	<0.2	0.001	0.4	0.003
Toluene	3	<0.001	<0.5	<0.001	<0.5	0.002
Ethylbenzene	4	<0.001	<1	<0.001	2	0.002
Xylenes (total)	<3	<0.003	<3	<0.003	<3	<0.003
Styrene (vinyl benzene)	22	0.004	<1 – 1*	0.006	3	0.005
Other MAHs	<1	--	<1	--	<1	--
Polycyclic aromatic hydrocarbons (PAH)						
Benzo(a)pyrene	<1	<0.001	<1	<0.001	<1	<0.001
Naphthalene	13	<0.001	<2	<0.001	<2	<0.001
Other PAHs	<1 to <4	<0.001	<2 to <4	<0.001	<2 to <4	<0.001
Polycyclic aromatic hydrocarbons (total)	13	ND	ND	ND	ND	ND
Phenols						
Phenol	29	<0.001	<4	<0.001	28	<0.001
Trichlorophenol (2,4,5-trichlorophenol)	<4	<0.001	<4	<0.001	<4	<0.001
Trichlorophenol (2,4,6-trichlorophenol)	<4	<0.001	<4	<0.001	<4	<0.001
Cresol (total)	ND	ND	ND	ND	ND	ND
Phenols (total)	29	ND	ND	ND	28	ND
Inorganic species						
Antimony	<7	--	<7	--	<7	--
Arsenic	<4	--	<4	--	<4	--
Barium	<1	--	2	--	<1	--
Beryllium	<1	--	<1	--	<1	--
Boron	<3	--	<3	--	<3	--
Cadmium	<0.4	--	<0.4	--	<0.4	--
Chromium	<1	--	3 – 4 *	--	<1	--

Contaminant	Reported concentration [1]					
	Rockhampton		Gold Coast		Toowoomba	
	Total concentration (mg/kg)	Leachable concentration, neutral pH (mg/L)	Total concentration (mg/kg)	Leachable concentration, neutral pH (mg/L)	Total concentration (mg/kg)	Leachable concentration, neutral pH (mg/L)
Chromium (hexavalent)	<1	--	<1	--	<1	--
Copper	2	0.001	21 – 23	0.006	<1	<0.001
Lead	<1	--	<1 – 1	--	<1	--
Mercury	<0.1	--	<0.1	--	<0.1	--
Molybdenum	<1	--	<1	--	<1	--
Nickel	<1	--	2	--	<1	--
Selenium	<2	--	<2	--	<2	--
Silver	<1	--	<1	--	<1	--
Vanadium	2	<0.001	4 – 5 *	<0.001	<1	<0.001
Zinc	<1	--	13	--	<1	--
Other						
pH (units)	9.4	--	10.2	--	9.0	--

Notes:

Refer to **Appendix B** for further information.

“--" = Indicates no data available.

“*” = Indicates range based on internal laboratory quality control analysis.

ND = Not detected.

1 = COA 311229 or COA 311229-A unless otherwise indicated.

2 = COA 311229-B.

Review of **Table 2.2** indicates that the main key chemicals detected in waste RPM were TRH >C10. There was some variability in TRH concentrations both between and within the waste RPM from the 3 different sources, with the concentrations in the waste RPM from Rockhampton being most variable (this can be seen from the TRH concentrations where the analysis was repeated to allow SGC analysis). SGC analysis had limited to no impact on the reported TRH concentrations, indicating that the TRH in waste RPM is petroleum based (likely due to the affixed asphalt which was not removed prior to disposal).

Low concentrations of TRH C6-C9, benzene, toluene, ethylbenzene, styrene, naphthalene, phenol and some metals were also reported in waste RPM.

The leachability analysis indicated that the TRH is not leachable i.e. bound in the waste RPM.

2.2.3 Waste categorisation

In this section of the assessment, concentrations of key chemicals detected in waste RPM have been compared to the categorisation thresholds from DES (2022a), to confirm the waste categorisation. As indicated in **Section 1.1**, waste RPM are currently disposed of as Category 1 regulated waste.

Table 2.3 provides a review of detected concentrations of chemicals in the waste RPM with the categorisation thresholds.

Table 2.3: Comparison with categorisation thresholds, waste RPM

Chemical [1]	Maximum reported concentration (mg/kg)			Waste categorisation thresholds (DES 2022a) (mg/kg)		
	Rockhampton	Gold Coast	Toowoomba	Not regulated	Category 2 regulated waste	Category 1 regulated waste
pH (units)	9.4	10.2	9.0	6.5 – 9	2 – <6.5 or >9 – 12.5	<2 or >12.5
Petroleum hydrocarbons (C6 to C9)	26	<25	68	<950	950 – 3,800	>3,800
Petroleum hydrocarbons (C10 to C36)	7,800	15,000	5,700	<5,300	5,300 – 21,200	>21,200
Benzene	<0.2	<0.2	0.4	<5	5 - 20	>20
Toluene	3	<0.5	<0.5	<1,470	1,470 – 5,880	>5,880
Ethylbenzene	4	<1	2	<17	17 – 68	>68
Styrene	22	1	3	<1,800	1,800 – 7,200	>7,200
Polycyclic aromatic hydrocarbons (total)	13	<1	<1	<300	300 – 1,200	>1,200
Phenols (total)	29	ND	28	<40,000	40,000 – 160,000	>160,000
Barium	<1	2	<1	<4,500	4,500 – 18,000	>18,000
Copper	2	23	<1	<220	220 – 880	>880
Lead	<1	1	<1	<300	300 – 1,200	>1,200
Nickel	<1	2	<1	<1,200	1,200 – 4,800	>4,800
Vanadium	2	5	<1	<117	117 - 468	>468
Zinc	<1	13	<1	<400	400 – 1,600	>1,600

Notes:

Refer to **Appendix B** for further information. Shading indicates an exceedance of the waste categorisation threshold. Total chromium not listed as hexavalent chromium was not detected in waste RPM and the waste categorisation threshold is for hexavalent chromium.

Review of **Table 2.3** indicates that waste RPM are categorised as Category 2 regulated waste.

In addition, concentrations of TRH C10-C36 (the main contaminant) are only just above the threshold for non-regulated waste (maximum reported concentration of 5,700 mg/kg exceeding the threshold of 5,300 mg/kg; noting also that 1 sample reported a concentration of 5,100 mg/kg). Concentrations of all other chemicals and pH in waste RPM from Toowoomba are below the thresholds for non-regulated waste. The waste RPM from Toowoomba are the "cleanest" RPM (with the least asphalt attached; refer to **Exhibit 2.2**).

Hence, there is the possibility that waste RPM may be able to be disposed as non-regulated waste where most of the asphalt can be removed from the waste RPM prior to disposal. This would need to be confirmed through further laboratory analysis of "clean" or "cleaner" waste RPM.

2.2.4 Recommendations

There are no recommendations arising from this section of the review.

2.3 Wash water

2.3.1 Key chemicals of relevance

The key chemicals of relevance for wash water were determined as part of the enRiskS interim technical review where it was concluded that all chemicals listed in Table 4a and Table 4b of Appendix 4 of DES (2022a) were identified as key chemicals for this assessment, except for:

- peroxides (item 5)
- asbestos (item 6)
- fluoride (item 26)
- polycyclic aromatic hydrocarbons (PAH) (items 6 and 42)
- dinitrotoluene (item 24)
- specific persistent organic pollutants (POPs) (items 22, 1, 33, 34, 41 and 36).

In addition, analysis for per-and poly-fluoroalkyl substances (PFAS) (standard analysis and Total Oxidisable Precursor Analysis; TOP Assay), ammonia, biological oxygen demand (BOD), chemical oxygen demand (COD) and suspended solids was recommended.

A copy of the enRiskS interim technical review with the justification of key chemicals is provided in **Appendix A**.

2.3.2 Available data

One sample of wash water (sample DSW1) was initially provided to Envirolab for analysis as per the recommendations of the enRiskS interim technical review. The available data is provided in **Appendix B**.

Key chemicals of relevance detected in the wash water comprised:

- phenol and m/p-cresol
- PFAS
- ammonia
- metals (arsenic, barium, boron, cadmium, total chromium, copper, nickel and lead).

Total cyanide and chromium VI were reported below the laboratory limit of reporting (LOR). LORs for some other chemicals (which were reported below the LOR) were raised due to sample matrix interference. The pH of the wash water was 7.3 units, the electrical conductivity (EC) was 2,100 µS/cm, the total suspended solids was 660 mg/L, the BOD was 5,170 mg/L and the COD was 7,800 mg/L.

The following PFAS were detected in the wash water with standard analysis:

- Perfluoropentanoic acid (PFPeA) – 0.83 µg/L
- Perfluorohexanoic acid (PFHxA) – 0.88 µg/L
- Perfluoroheptanoic acid (PFHpA) – 0.14 µg/L

The following PFAS were detected in the wash water with TOP Assay analysis:

- Perfluorobutanoic acid (PFBA) – 0.28 µg/L
- PFPeA – 0.77 µg/L
- PFHxA – 0.66 µg/L
- PFHpA – 0.11 µg/L.

The detected PFAS are the C4 to C7 carboxylic acids. Perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS) and perfluorooctanoic acid (PFOA) were reported below the LOR. Based on enRiskS' experience, this means that the source of the PFAS is unlikely to be historical firefighting activities (where the PFAS signature is normally dominated by PFOS). The similarity of reported PFAS and concentrations pre- and post TOP Assay indicates that significant concentrations of precursors are unlikely to be present. However, and as noted above, the LORs for several PFAS are raised due to sample matrix interference. For example, the LOR for PFOS, PFHxS and PFOS is 0.1 µg/L which is significantly above the target LOR of 0.0002 µg/L.

The detection of PFAS in the wash water is unexpected as PFAS were included as key chemicals of relevance for completeness, rather than because they were expected to be present in the paint wash water. The detected PFAS may be due to presence in the paint or may also be due to cross contamination during preparation, use, storage and/or handling. It is noted that PFAS are present in many "every day" products and are also considered to be ubiquitous in the environment in urban parts of Australia, where they have been detected in potable water supplies, as well as soil and groundwater/surface water/tank water. PFAS may also be present in domestic house paint, which are categorised as non-regulated waste in Queensland.

2.3.3 Waste categorisation

The detection of PFAS in the wash water restricts disposal as the threshold level for PFAS in liquid waste in DES (2022a) is "zero" which means "*…less than the LOR… where the test selected has an LOR that is the best achievable for the parameter*". Where PFAS is reported in a waste above the LOR, the waste is categorised as Regulated. This means that wash water remains categorised as a Category 2 regulated waste.

Wash water is also categorised as Regulated based on reported concentrations of copper, zinc, EC and BOD.

In addition, and as noted in **Section 2.3.2**, the LOR for many chemicals are raised.

2.3.4 Recommendations

The following is recommended based on the assessment undertaken:

1. Request information on whether PFAS are present in the water-based paints used for line marking, including any laboratory analysis results to confirm presence/absence at the LOR that is possible for the waste (i.e. in consideration of matrix interference).
2. Confirm the wash water life cycle to determine the key stages where PFAS may be added to the wash water. i.e. which products are used in the process, where do these products come from and might they contain PFAS?
3. Review procedures at storage and handling sites to identify if there is the potential for environmental cross contamination.
4. Analyse samples of the products from the key lifecycle stages for PFAS.

ARRB and TMR could also consider analysing wash water sourced from domestic house paints for PFAS. Where PFAS is detected in wash water from domestic paints, a further discussion in relation to the relevance of the detection of PFAS in wash water from line marking paints could be initiated with DES.

Section 3. Risk assessment for beneficial re-use of waste RPMs

3.1 General

This section of the assessment comprises review of the potential risks to human health and the environment following the re-use of waste RPM in the following applications:

- Application 1 – partial aggregate replacement in asphalt.
- Application 2 – use in materials underlying asphalt (entombing the waste RPM, where a new asphalt road is laid over an older asphalt road with RPMs affixed).

Neither of the above applications are expected to change the chemical characteristics of the materials. Hence, human health and environmental risk profiles are not expected to change.

For Application 2, the waste RPM would remain on the road, however, a new trafficable surface would be laid on top. Hence, there would be no potential for human health or environmental exposures to any chemicals in waste RPM, and where there is no potential for exposure to waste RPM, there are no risks from waste RPM. Application 2 is a less sensitive scenario from a human health and ecological perspective than the existing use of RPM on roads.

For Application 1, the key chemical of relevance in waste RPM is TRH >C10, which is likely to be due to the presence of asphalt affixed to the RPM. This can be seen from the available results (refer to **Section 2.2**), where waste RPM with more asphalt reported higher concentrations of TRH, and waste RPM with variable amounts of affixed asphalt reported variable concentrations of TRH. Hence, using waste RPM as a partial aggregate replacement in asphalt is not expected to change the TRH concentrations in the asphalt.

Several other key chemicals were detected in the waste RPM, including monocyclic aromatic hydrocarbons (MAH; including benzene), naphthalene, phenols and metals (barium, copper, lead, nickel, vanadium and zinc). It is not clear if these chemicals are sourced from the asphalt, the bitumen adhesive and/or the plastic RPM body.

In May 2022, enRiskS completed a *Technical Review: Reclaimed Asphalt Pavement in Road* for ARRB and TMR (enRiskS 2022). This assessment included data for concentrations of chemicals in reclaimed asphalt pavement (RAP). The reported concentrations of chemicals in RAP are presented in **Table 3.1** alongside the data for concentrations of chemicals in the waste RPM.

Table 3.1: Chemicals detected in RAP and waste RPM

Chemical	Reported concentration range (mg/kg)	
	RAP (enRiskS 2022)	Waste RPM
TRH F2 (>C10-C16 minus naphthalene)	<500 – 53	<500 – 1,700
TRH F3 (>C16-C34)	1,200 – 1,600	3,000 – 13,000
TRH F4 (>C34-C40)	1,300 – 1,800	1,400 – 7,800
Arsenic	5.6 – 11	<4
Barium	37 – 200	<1 – 2
Copper	23 – 87	<1 – 23
Lead	5 – 7	<1 – 1
Nickel	18 – 30	<1 – 2

Chemical	Reported concentration range (mg/kg)	
	RAP (enRiskS 2022)	Waste RPM
Vanadium	47 – 58	<1 – 5
Zinc	42 – 47	<1 – 13
pH	8.5 – 9.4	9.0 – 10.2

Notes:

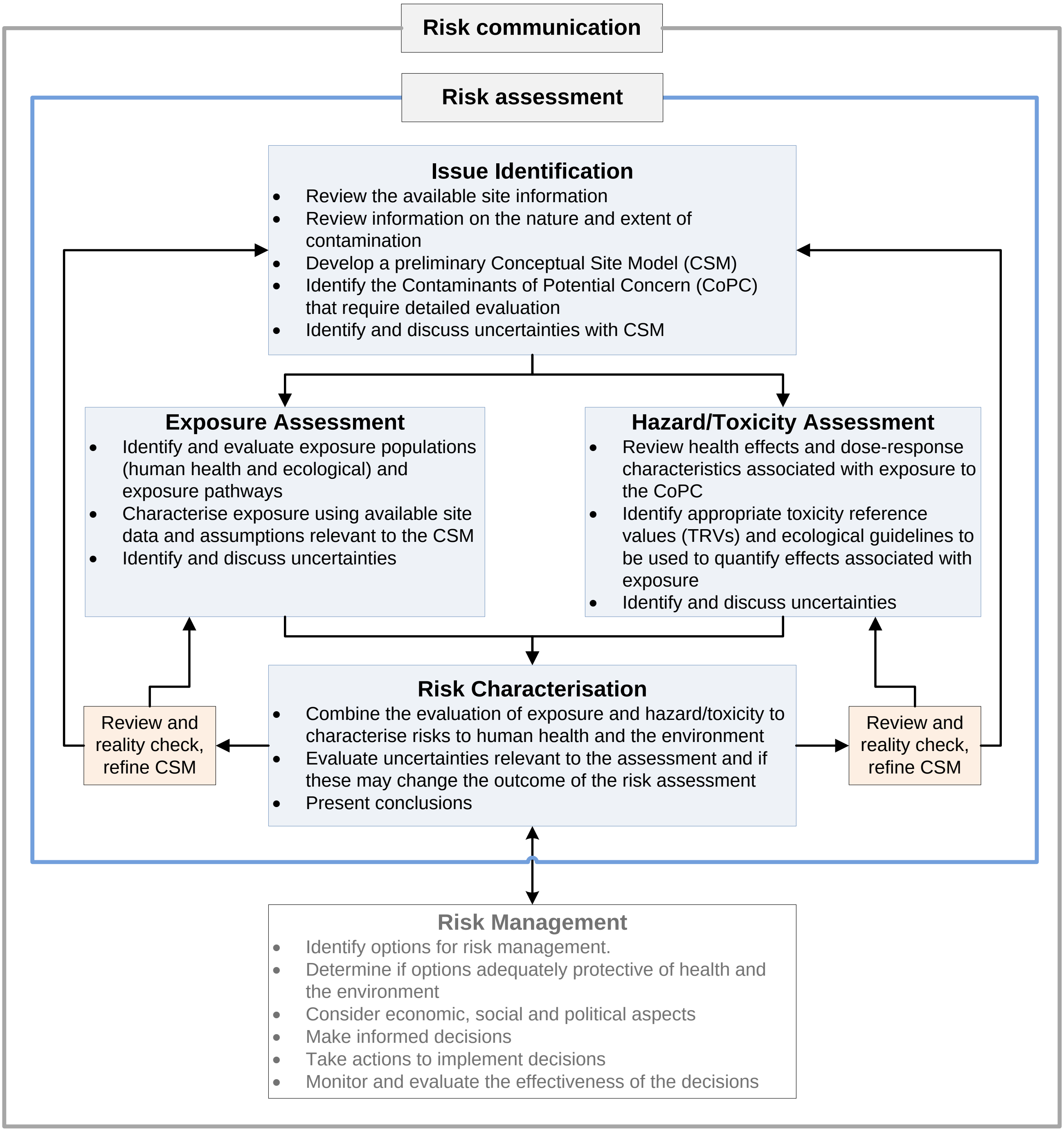
1 = enRiskS (2022), *Technical Review: Reclaimed Asphalt Pavement in Road*, May 2022.

Review of **Table 3.1** indicates that concentrations of metals in waste RPM are similar to or lower than in RAP. Hence, the addition of the RPM and binder has not increased the concentrations of metals compared to what is already present in the RAP.

Concentrations of TRH in the waste RPM are higher than in the RAP. As discussed above, this is likely to be due to the variability in the asphalt. However, MAH, naphthalene and phenols were detected in the waste RPM but not in the RAP. Given this, a screening level human health and ecological risk assessment (HHERA) has been undertaken.

The HHERA has focused on Application 1 which is the use of waste RPM as partial aggregate replacement in asphalt, which is a more sensitive re-use than Application 2.

The overall approach for the HHERA is outlined in the following (modified from enHealth 2012):



3.2 Conceptual site model

3.2.1 Receptors

As indicated in **Section 3.1**, this assessment has addressed human health and environmental risk issues relevant to the use of waste RPM as partial aggregate replacement in asphalt.

On this basis, the identified receptors are:

- workers (adults)

- members of the general public (adults and children)
- the environment, i.e. the terrestrial and aquatic ecosystems at and/or downgradient of the re-use site as well as any intermediate storage or transport sites.

The identified receptors may be exposed to total chemical concentrations in waste RPM or leachable chemical concentrations in waste RPM, depending on the exposure pathway. Further discussion is provided in below**.**

3.2.2 Exposure pathways, total chemical concentrations

Relevant pathways

The key exposure pathway relevant to total concentrations of chemicals in waste RPM during use as partial aggregate replacement in asphalt is incidental direct contact with chemicals by people and ecological receptors (flora, fauna etc.). Incidental direct contact exposures may occur where people or organisms live in or have access to (come into contact with) waste RPM. The potential for workers, members of the public and ecological receptors to be exposed to total concentrations of chemicals in waste RPM via incidental direct contact is discussed below.

Workers

Workers may come into incidental direct contact with asphalt materials containing waste RPM, where the following may occur:

- incidental ingestion – where a small amount of a material with contaminants is inadvertently consumed e.g. with lunch, where hands are not washed properly
- dermal contact – where a material with contaminants comes into contact with bare skin
- inhalation of dust – where a fine material with contaminants is inadvertently inhaled.

Potential risks to workers following incidental direct contact with waste RPM are assessed in **Section 3.3**.

Members of the public

Members of the public are not expected to be directly exposed to waste RPM. The potential for exposure to occur will be limited or entirely mitigated by the control measures that will be required to be implemented to ensure that the pollution of the environment does not occur during activities with waste RPM. This includes limiting public access to construction sites and roads under construction, as is required for general health and safety.

Hence, potential exposures to total concentrations of chemicals in waste RPM by members of the public are considered to be incomplete and have not been assessed further in the HHERA.

Terrestrial and aquatic environment

Terrestrial and aquatic ecological receptors (or ecosystems) that require protection are not expected to be present (or encouraged) at industrial sites that handle waste RPM, on construction sites or beneath asphalt roads (the presence of the road surface will limit the presence of any ecosystem underneath the road).

Waste RPM are extremely hard and brittle (refer to **Section 2.2**), hence, dust is not expected to be generated from waste RPM.

Based on the above, terrestrial and aquatic ecosystems are not expected to be regularly exposed (or exposed at all) to concentrations of total chemicals in waste RPM. Hence, potential exposures to total concentrations of in waste RPM by terrestrial and aquatic ecosystems are considered to be incomplete and have not been assessed further in this HHERA.

3.2.3 Exposure pathways, leachable chemical concentrations

They potential exposure pathways relevant to leachable concentrations of chemicals in waste RPM is the direct contact with chemicals by humans and aquatic ecosystems following the leaching and/or surface runoff of chemicals from waste RPM into the environment.

Where waste RPM are physically and chemically (including hydraulically) bound in asphalt, there is a negligible potential for exposure with chemicals by people or the environment. This is because the chemicals are locked away or bound up as the asphalt is produced.

The creation of bound products such as asphalt can also be referred to as solidification and the Australian National Remediation Framework (NRF) (CRC CARE 2019) indicates that reagents have been used as a way of solidifying contaminants in soil for many years. Solidification is defined by the NRF as follows:

> "*The addition of cementitious reagents to contaminated soil to encapsulate the waste materials within the matrix and change its physical properties, reducing its permeability and the extent to which contaminant migration will occur either into or from the treated medium.*"

The information in the NRF is supported by information from the USEPA where it is indicated that solidification is an established technology that has been used for almost 20 years at Superfund remedial sites. The USEPA define solidification as the process of encapsulation to form a solid material. This restricts chemical migration by decreasing the surface area exposed to leaching and/or by adding a coating with low-permeability materials. Solidification of a large block is referred to as microencapsulation (USEPA 2000).

The solidification/binding process described above means that the following potential exposure pathways can be considered incomplete:

- the release of contaminants from bound products into the environment (due to a reduced surface area for leaching as the bound product is less permeable or impermeable to water and the chemicals are encapsulated)
- the potential for the incidental ingestion of, or dermal contact with, small particles that may be sourced from the product (which could be incidentally ingested by hand to mouth contact

or may stick onto the skin to allow dermal absorption (due to encapsulation in a solid material)
- the inhalation of dust sourced from the bound products (unless the products are broken up or mechanically handled).

Potential exposures to contaminants in asphalt are further minimised by where the asphalt is placed (i.e. on a road, car park or footpath etc.).

Where there are no exposures to chemicals (including environmental contaminants) in the waste RPM, there are no human health or environmental risks from chemicals in the waste RPM, and no need for any detailed assessment of risks.

Hence, further consideration of potential risks from chemicals following the use of waste RPM as a partial aggregate replacement in asphalt is not required in this HHERA.

3.3 Human health risk assessment

3.3.1 Review of total concentrations of chemicals

This section of the HHERA comprises an evaluation of potential risks to the health of workers who may handle waste RPM from total concentrations of chemicals in waste RPM. Based on the information presented in **Section 3.2**, there are no relevant ecological receptors or complete exposure pathways that require further evaluation in this HHERA.

This assessment has comprised the comparison of total concentrations of chemicals detected in waste RPM against the screening level guidelines for soil available in the ASC NEPM i.e. the health based investigation and screening levels (HILs and HSLs). This guidance provides national risk-based screening level guidelines for several generic exposure settings including residential, open-space/parks/recreational and commercial/industrial land uses (CRC CARE 2011; NEPC 1999 amended 2013a). The HIL/HSLs have been developed to be protective of human health and do not consider environmental risk issues.

The HIL/HSL-D values for soil in a commercial/industrial setting (which includes industrial sites) have been adopted for this assessment. The HIL/HSL-D values are relevant for the assessment of potential direct contact risks to workers and assume that exposures to chemicals in waste RPM occur regularly as follows:

- incidental ingestion of 25 mg per day for adults every day of the year for 30 years
- the waste RPM comes into contact with 20% of the skin surface area for adults every day of the year for 30 years – the calculations assume the chemical stays on the skin until the next shower
- inhalation of dust sourced from the waste RPM by adults for 1 hour every day of the year for 30 years (this is a minor contributor to the guideline, however, as noted above is not expected to be relevant).

Where HIL values are not available for a particular analyte, the risk-based regional screening levels (RSLs) for soil from the USEPA (USEPA 2022) for an industrial setting have been adopted.

Total chromium has not been included in the screening level assessment as the HIL values for chromium are for chromium VI and chromium VI was not detected in waste RPM (the chromium detected in waste RPM is the less toxic form, chromium III), and there are no health risk issues related to the total chromium concentrations reported.

Table 3.2 presents a summary of the maximum concentrations of chemicals detected in the waste RPM with the adopted screening level guidelines. Chemicals of potential concern (CoPC) that require further consideration in this assessment are those where the concentrations exceed the adopted screening level guideline.

Table 3.2: Screening level assessment for the protection of human health (workers)

Chemical (or indicator) [1]	**Total concentration in the waste RPM (maximum) (mg/kg)**	**Adopted screening level guideline (mg/kg)**
		Workers, direct contact
pH (units)	9.0 – 10.2	6-8 [A]
Chemicals detected in the waste RPM		
Barium	2	220,000 [U]
Copper	23	240,000 [N]
Lead	1	1,500 [N]
Nickel	2	6,000 [N]
Vanadium	5	5,800 [U]
Zinc	13	400,000 [N]
TRH F1 (C6-C10 minus BTEX)	77	26,000 [C]
TRH F2 (>C10-C16 minus naphthalene)	1,700	20,000 [C]
TRH F3 (>C16-C34)	13,000	27,000 [C]
TRH F4 (>C34-C40)	7,800	38,000 [C]
Benzene	0.4	430 [C]
Toluene	3	99,000 [C]
Ethylbenzene	4	27,000 [C]
Styrene	22	35,000 [U]
Naphthalene	13	11,000 [C]
Phenol	29	240,000 [N]

Notes:

Shading indicates an exceedance of the adopted screening level guideline.

1 = Units are mg/kg otherwise indicated.

A = 1992 ANZECC B levels adopted in the absence of a HIL or RSL.

C = Ref. CRC CARE (2011) direct contact HSL-D values for a commercial/industrial land use adopted for the protection of workers.

N = Ref. NEPM (2013) HIL-D values for a commercial/industrial land use adopted for the protection of workers.

U = Ref. USEPA (November 2022) RSLs for soil in an industrial setting adopted for the protection of workers and based on a target risk level of 1 for threshold health effects and $1x10^{-5}$ for non-threshold health effects.

Review of **Table 3.2** indicates that total concentrations of all chemicals in waste RPM are below the adopted screening level guidelines. Hence, there are no health risk issues of concern in relation to incidental direct contact exposures to chemicals in waste RPM by workers during use of this material as a partial aggregate replacement in asphalt.

The pH of the waste RPM is alkaline and outside of the adopted screening level guideline range (i.e. ANZECC B levels). This is also expected to be the case for asphalt and other aggregate materials, however, further assessment is presented in **Section 3.3.2** of this HHERA for completeness.

3.3.2 Further assessment for pH

The key human health risk issue for the direct contact with materials with an alkaline pH is the potential for skin irritation and burns. One example of this is the skin effects that can occur following the handling of fresh cement and concrete mixes[1]. The ADWG (NHMRC 2011 updated 2022) indicates that liquids with pH values of less than 4 units and above 11 units may result dermal effects to people

The natural pH of the surface of normal skin (the stratum corneum) is in the range 4.1 – 5.8 (95% interval with an arithmetic mean of 4.9) (Proksch 2018) and the pH of skin is more neural in newborns, decreasing significantly in the first 2 months of life (Panther & Jacob 2015; Proksch 2018). Skin has a very good buffering capacity, and exposures to alkaline materials occur during everyday life. For example, soap and toothpaste are alkaline materials (pH of approximately 7 to 11 units) and these materials are well tolerated by people, as are exposures to set concrete and asphalt surfaces. The skin's buffering capacity can, however, be reduced by repeated exposure e.g. with regular use of water and detergent. A low buffer capacity of the skin (and hence increased sensitivity to products such as soap and detergents) has been reported for babies, aged individuals and diseased skin (Proksch 2018).

The pH of the waste RPM (9 to 10 units) is within the ADWG dermal range, hence, no adverse dermal effects are expected. This also assumes that workers do not adopt any occupational health and safety controls, for example the use of personal protective equipment (PPE), when handling the waste RPM and other asphalt materials.

In relation to exposures following incidental ingestion, the ADWG indicates that the consumption of food and beverages with quite low pH or high pH is common and does not result in adverse health effects. For example, the pH of carbonated beverages is 2.5 units, the pH of orange fruit juice is around 3.8 units and the pH of matcha green tea is around 9 units[2]. There are not normally any adverse health effects when these beverages are consumed as the pH of the consumed material rapidly changes to match the acidic pH of the stomach. This means that the alkaline pH of waste RPM is not a human health risk issue following exposures via incidental ingestion.

3.4 Uncertainties

This HHERA is based on data for 3 samples of waste RPM and indicates some variability in concentrations of chemicals in waste RPM.

However, review of **Table 3.2** indicates that the margin of safety (MOS) between maximum total concentrations of chemicals in the waste RPM and the adopted screening level guidelines is 2 to 10 times for TRH F2 to F4, >300 times for TRH F1, 900 times for naphthalene and > 1,000 times for all other chemicals.

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[1] Once set, where the upper surface of the concrete has undergone carbonation and the potential for concrete to result in skin irritation is low as the pH of the surface of the concrete is lower.

[2] Based on information available online.

In relation to the heavy end TRH:

- these concentrations are likely to be due to the presence of residual asphalt
- the adopted screening level guidelines (HSL-D values) are conservative for the assessment of worker exposures to TRH, e.g. assume that exposures to soil occur on 240 days/year for a working lifetime (the same worker is involved in handling waste RPM with no PPE for their working life).

Hence, it is concluded that there is adequate data for the HHERA.

This assessment of potential risks to workers has focused on the incidental direct contact pathway, which is the key pathway of relevance for the use of a small volume of waste RPM in aggregate for asphalt.

In addition, concentrations of individual volatile chemicals in the waste RPM are below the USEPA RSLs for residential use (USEPA 2022) (refer to **Table 3.3**). These RSLs consider direct contact exposures by people (incidental ingestion, dermal exposure and the inhalation of dust) as well as the inhalation of VOCs in outdoor air by people (as opposed to the vapour intrusion pathways considered in the derivation of the HSLs in the ASC NEPM). Many of these values are based on animal toxicity studies with safety factors to translate the animal studies to humans, hence, the RSLs are also considered protective of environmental receptors.

Table 3.3: Screening level assessment for the transfer of VOCs to the environment

Chemical (or indicator) [1]	**Total concentration in the waste RPM (maximum) (mg/kg)**	**Adopted screening level guideline (mg/kg)**
		USEPA RSL for residential use
Benzene	0.4	12
Toluene	3	4,900
Ethylbenzene	4	5.8
Styrene	22	6,000
Naphthalene	13	130 [1]

Notes:

Shading indicates an exceedance of the adopted screening level guideline.

U = Ref. USEPA (2022) RSLs for soil in a residential setting, based on a target risk level of 1 for threshold health effects and $1x10^{-5}$ for non-threshold health effects.

1 = Threshold value adopted consistent with the mechanisms of action.

Section 4. End of waste considerations

4.1 Issue identification

Section 3 of this assessment reviewed the potential human health and ecological risk issues associated with the use of waste RPM as a partial aggregate replacement in asphalt.

However, the Queensland Government *End of Waste Code for Recycled Aggregates* (ENEW07604819) (October 2021) indicates that:

> "*…all reasonable and practicable measures have been taken to ensure that recycled aggregates are segregated from other waste material.*"
>
> and
>
> "*'**other waste material**' means non-aggregate materials, including but not limited to, other wastes and recyclable materials, plastic, metal, plaster, rubber, wood, cloth, carpet, insulation materials and/or regulated waste.*"

Hence, End of Waste (EOW) code ENEW07604819 does not allow for the presence of plastic which would be present where waste RPM were recycled for use in aggregates.

As discussed in **Section 3.2** and **Section 3.3**, there are no human health or ecological risk issues of concern where waste RPM are used for partial aggregate replacement in asphalt. In addition, the available data suggests that most of the chemicals detected in the waste RPM are due to the presence of residual asphalt affixed to the RPM (and not the plastic RPM body or the binder). Hence, the available data does not suggest that a separate EOW code for waste RPM would be necessary.

It is also not clear if waste RPM would be suitable for use in any other type of aggregate e.g. aggregate used as pipe bedding, for construction purposes, as road base or as a drainage material.

Irrespective of the above, this assessment has considered the potential for human health and ecological risk issues from the unrestricted use of waste RPM in recycled aggregates, to inform whether an application for an EOW approval for waste RPM may be worthwhile.

4.2 Exposure scenarios

4.2.1 General

If it was assumed that waste RPM may be used in recycled aggregates, the difference between this re-use scenario and the re-use of the waste RPM in asphalt (as assessed in **Section 3**), is the following:

- these scenarios could be classified as unbound applications, where the run-off and/or leaching of chemicals to the environment may occur
- there is the potential (albeit low) that aggregates with waste RPM could be re-used beneath buildings, where concentrations of VOCs in the materials could intrude into overlying enclosed spaces.

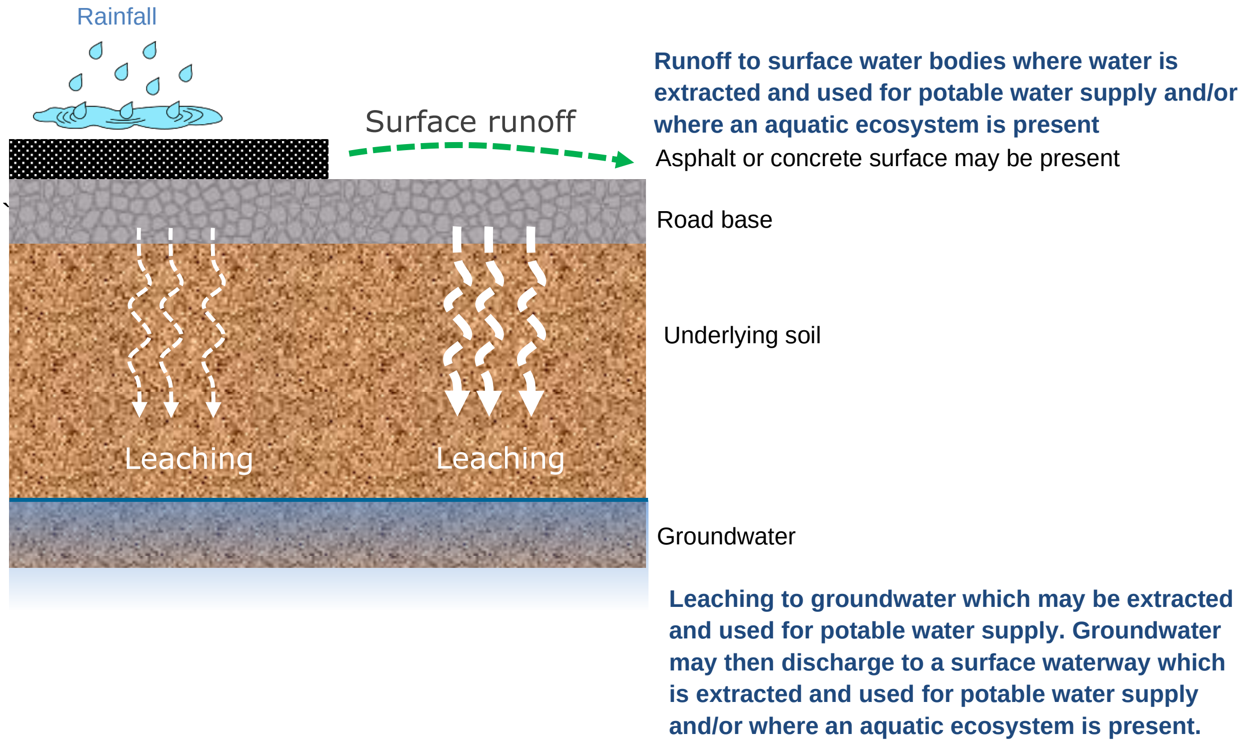
4.2.2 Unbound re-use scenarios

Overview

For unbound re-use scenarios, exposures with chemicals sourced from waste RPM could occur via incidental ingestion and/or dermal contact, where concentrations of chemicals in the waste RPM leach and/or runoff into the environment, are transported to groundwater or surface water, and/or discharge from groundwater to surface water, and where:

- this water is subsequently extracted and used
- an aquatic ecosystem that requires protection is present.

These pathways are illustrated on **Figure 4.1**.



Runoff to surface water bodies where water is extracted and used for potable water supply and/or where an aquatic ecosystem is present

Leaching to groundwater which may be extracted and used for potable water supply. Groundwater may then discharge to a surface waterway which is extracted and used for potable water supply and/or where an aquatic ecosystem is present.

Figure 4.1: Summary of potential exposure pathways – leachable concentrations of chemicals

The potential for surface water runoff and leaching to the environment will depend on the re-use scenario, as discussed further below.

Potential for surface water runoff

The potential for surface runoff depends on the materials overlying the aggregate containing waste RPM. For example, there is the potential for the surface runoff of chemicals where waste RPM are used in aggregate uncompacted at the land surface. However, there is less potential for surface runoff to contain chemicals when waste RPM are used in aggregate that is compacted and/or a permeable material is placed over the aggregate. Where waste RPM are used in aggregate that is compacted and placed underneath a sealed surface (e.g. road base sealed with asphalt or concrete), there is limited or no potential for the runoff of chemicals from waste RPM to the environment.

Potential for leaching

The key factor that affects the potential for the leaching of chemicals from waste RPM to groundwater and/or surface water is the porosity of any materials overlying the aggregate with waste RPM (where present) and the rate of water infiltration through the waste RPM and these overlying materials. The infiltration rate describes the gradual movement of water (rainwater or stormwater) through an unsaturated zone comprising layers of soil (or other materials including pavements). The infiltration rate is directly related to the permeability of the materials and the permeability of the materials is dependent on the porosity of the materials. This process is very different to the movement of water in a saturated zone, such as an aquifer, where there is a hydraulic head which causes flow under pressure.

Unsealed applications have the highest potential for the leaching of chemicals from the waste RPM. Where a material is used underneath a sealed surface, there is a lower potential for the leaching of chemicals in the waste RPM into the environment, or no potential for leaching (e.g. when a material is used beneath a building slab).

Transport of chemicals in the environment

Concentrations of leachable chemicals in waste RPM are not the concentrations of chemicals that will be present in water that may be extracted for use or in groundwater discharging to a waterway that contain an aquatic ecosystem. There will be some dilution and attenuation of chemicals concentrations as the chemical is transported from waste RPM to groundwater and/or the waterway where human and environmental receptors are present, and where exposures could occur. This is due to the physical processes that occur naturally in the environment.

This means that human and ecological receptors will not be exposed to leachable concentrations of chemicals in waste RPM i.e. the leachable concentrations are not the exposure point concentrations. The concentrations that receptors may be exposed to will be lower than those that are present in the waste RPM. For this reason, the assessment (through modelling or measurement) of exposure point concentrations is standard practice for a risk assessment as per the ASC NEPM framework (NEPC 1999 amended 2013a).

This concept was first recognised formally by USEPA during the development of their 1996 Soil Screening Guidance (USEPA 1996) (which was then incorporated into Australian guidance) i.e.:

- "*As contaminants in soil leachate move through soil and ground water, they are subjected to physical, chemical, and biological processes that tend to reduce the eventual contaminant concentration at the receptor point. These processes include adsorption onto soil and aquifer media, chemical transformation (e.g., hydrolysis, precipitation), biological degradation, and dilution due to mixing of the leachate with ambient ground water*".

As such, USEPA developed a methodology for modelling the migration of chemicals from soil to a groundwater receptor. The model developed by USEPA has 2 stages:

- Stage 1: release of the chemical to soil leachate

- Stage 2: transport of the chemical (as soil leachate) through the underlying soil and aquifer to a receptor (assumed by USEPA to be a groundwater well used for potable water supply).

The methodology utilised a soil/water partition equation for Stage 1 and a water-balance equation to calculate a dilution attenuation factor (DAF) for Stage 2. The Stage 2 DAF represents the reduction of the chemical in soil leachate by mixing in groundwater, expressed as the ratio of the leachable concentration to the receptor point concentration. The derivation of the DAF value for Stage 2 is based on several parameters including source length, infiltration rate and aquifer properties (hydraulic conductivity and gradient, and aquifer thickness).

Based on the above, the application of a DAF has been considered in this assessment, when assessing potential human health and ecological risks from leachable concentrations of chemicals in waste RPM. This assessment has applied a DAF to account for the reduction of chemical concentrations in the environment that is likely to occur due to the following physical processes, based on the way the aggregates with waste RPM may be used. This assessment is provided in **Section 4.3**.

4.2.3 Use of aggregates with waste RPM underneath buildings

VOCs have been detected in waste RPM, and if waste RPM are used in recycled aggregates for the construction of a building (e.g. as bedding material underneath a slab), there is the potential for the intrusion of VOCs into the building.

Maximum concentrations of benzene, ethylbenzene and toluene in waste RPM are below the ASC NEPM soil HSLs for vapour intrusion in a residential setting (HSL-A values). However, concentrations of TRH F1, TRH F2 and naphthalene exceed these HSLs.

It is not anticipated that waste RPM could be used in sufficient quantities in recycled aggregates such that vapour intrusion risks could occur. However, the potential for this sort of re-use, and any further details including proportion of waste RPM in aggregates, are unknown.

Hence it is concluded that waste RPM are not suitable for use in recycled aggregates placed underneath buildings without further information or assessment.

4.3 Risk assessment for leachable chemical concentrations

4.3.1 Approach

General

This section of the HHERA comprises an evaluation of potential risks to human health and the environment following the use of aggregates containing waste RPM, where chemicals in the waste RPM may be transported into the adjacent environment.

The assessment of potential risks to human and ecological receptors has been based on leachable concentrations of chemicals (including environmental contaminants) and the following approach:

- review against conservative screening level guidelines for the protection of human and ecological receptors in areas downgradient of the re-use location

- where the conservative screening level guidelines are exceeded, application of conservative DAF value.

The second step in the above approach recognises that concentrations of leachable chemicals in the waste RPM are not the chemical concentrations that receptors will be exposed to. Receptors will be exposed to lower chemical concentrations that are a function of the reported chemical concentrations and a DAF representing the physical processes that will occur in the environment. It is noted that where leachable chemical concentrations are below the adopted screening level guidelines in the first step of the process, it can be concluded that human health and ecological risks are low and acceptable, and there is no need to progress to the second step.

The adopted screening level guidelines and DAF are detailed below.

Adopted screening level guidelines

General

This review of risk issues considers the protected environmental values (EV) of groundwater and surface water under the Queensland Government Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (DES 2019). These are detailed in **Appendix C** where it is determined that the application of the Australian Drinking Water Guidelines (ADWG) (NHMRC 2011 updated 2022) and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) (ANZG 2018) for a 99% species protection level are protective of all EVs. These guidelines are discussed further below.

Human health

The ADWG (NHMRC 2011 updated 2022) have been adopted for the protection of the health of members of the public who may come into contact with water which contains concentrations of chemicals sourced from waste RPM.

As discussed in **Appendix C**, the ADWG are concentrations which, based on present knowledge, do not result in any significant risk to the health of a consumer of the water over a lifetime. These guidelines are recognised within the ASC NEPM (Schedule B6 Guideline on Risk Based Assessment of Groundwater Contamination, 1999 amended 2013) as relevant groundwater investigation levels for the assessment of human health issues at the point of extraction (for use as drinking water – protection of human health issues associated with use of water as domestic supply within households). The ADWG include aesthetic based as well as health-based guidelines. Aesthetic-based guidelines considered issues such as taste, odour, potential for corrosion of pipes and fittings etc. Both sets of guidelines have been adopted in this assessment.

Aquatic ecosystems

The ANZG (ANZG 2018) have been adopted for the protection of the health of aquatic ecosystems who may come into contact with water which contains concentrations of chemicals sourced from waste RPM. Where water quality guidelines are not available from the ANZG, guidelines have been adopted from the Canadian Water Quality Guidelines for the Protection of Aquatic Life/Agriculture – Freshwater, Long term (CCME 2007).

As the re-use locations are not known, the 99% species protection guidelines have been adopted. The available guidelines have been adopted for all protection levels and water types (freshwater and marine), where specific guidelines for each protection level/water type are not available.

Dilution attenuation factors

A default DAF of 20 has been adopted consistent with the recommendations of the ASC NEPM, which remains the overarching guideline for the assessment of contamination or potential contamination in Australia, and also provides the recognised and required methodology for a HHERA in Australia. The default DAF of 20 was originally determined by USEPA (1996) prior to adoption by the ASC NEPM (in Schedule B5C) and is based on a review of data from a range of uncontrolled sites with varying source sizes, soil types and depths to groundwater. The default DAF of 20 applies to any uncontrolled site where a chemical is present in soil (or in this case the waste RPM) without any capping, compaction and/or management of any type.

A default DAF of 20 is also conservative for the runoff of chemicals into the environment (following rainfall) where waste RPM is used in aggregate with no surface cover.

As noted above, the default DAF of 20 does not include any consideration of management (capping etc.). Hence, the DAF of 20 is highly conservative for sealed and/or compacted re-use applications, such as the re-use of aggregates underneath roads. This approach has been adopted to assess the unrestricted use of recycled aggregates containing waste RPM.

4.3.2 Human health risk assessment

Table 4.1 presents a summary of the maximum concentrations of leachable chemicals detected in waste RPM with the adopted screening level guidelines for the protection of human health i.e. the ADWG. CoPC that require further consideration in this assessment are those where the concentrations exceed the adopted screening level guideline.

Table 4.1: Screening level assessment for the protection of human health (members of the public)

Chemical (or indicator)	**Maximum leachable concentration (neutral pH) (mg/L)**	**Adopted screening level guidelines (mg/L)**	
		Potable water use – aesthetic based	**Potable water use – health based**
Benzene	0.003	--	0.001 [A]
Toluene	0.002	0.025 [AE]	0.8 [A]
Ethylbenzene	0.002	0.003 [AE]	0.3 [A]
Styrene	0.006	0.004 [AE]	0.03 [A]
Copper	0.006	1 [AE]	2 [A]

Notes:

Shading indicates an exceedance of the adopted screening level guideline.

A = Health-based guideline adopted from the Australian Drinking Water Guidelines (NHMRC 2011 updated 2022).

AE = Aesthetic guideline adopted from the Australian Drinking Water Guidelines (NHMRC 2011 updated 2022).

NA = Not applicable, no aesthetic concerns identified in the ADWG.

Review of **Table 4.1** indicates that leachable concentrations of the following chemicals in waste RPM exceed the adopted screening level guideline for the protection of drinking water consumed by members of the public:

- benzene (health-based guideline)
- styrene (aesthetic-based guideline).

Revised guidelines for the protection of the health of members of the public, that have been derived based on the application of a DAF of 20 are presented in **Table 4.2**.

Table 4.2: Further assessment using modified guidelines for the protection of members of the public, DAF = 20

Chemical	Maximum leachable concentration (neutral pH) (mg/L)	Adopted screening level guidelines (mg/L)	
		Potable water use – aesthetic based	Potable water use – health based
Benzene	0.003	--	0.02
Styrene	0.006	0.08	0.6

Notes:

Modified guideline = screening level guidelines from **Table 4.1** x 20.

Review of **Table 4.2** indicates that leachable concentrations of benzene and styrene in waste RPM are below the modified screening level guidelines for the protection of the health of members of the public, including the extraction and use of water for potable water supply.

Hence, there are no human health risk issues of concern for members of the public and the use of waste RPM in recycled aggregates.

4.3.3 Ecological risk assessment

Table 4.3 presents a summary of the maximum concentrations of chemicals detected in waste RPM with the adopted screening level guidelines for the protection of aquatic ecosystems i.e. the ANZG. CoPC that require further consideration in this assessment are those where the concentrations exceed the adopted screening level guideline.

Table 4.3: Screening level assessment for the protection of aquatic ecosystems

Chemical	Maximum leachable concentration (neutral pH) (mg/L)	Adopted screening level guidelines (mg/L)	
		99% species protection	99% species protection
		Freshwater	Marine and estuarine
Benzene	0.003	0.6 [A]	0.5 [A]
Toluene	0.002	0.11 [A]	0.11 [A]
Ethylbenzene	0.002	0.05 [A]	0.05 [A]
Styrene	0.006	0.072 [C]	0.072 [C1]
Copper	0.006	0.001 [A]	0.0003 [A]

Notes:

Shading indicates an exceedance of the adopted screening level guideline.

Guidelines for freshwater adopted for marine water where no marine specific guidelines available.

1 = Freshwater guideline adopted for marine water as no guideline available.

A = Ecological guideline from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

C = Canadian Water Quality Guidelines for the Protection of Aquatic Life/Agriculture – Long term, Freshwater (CCME 2007).

Review of **Table 4.3** indicates that leachable concentrations of copper in the waste RPM exceed the adopted screening level guidelines for the protection of aquatic ecosystems.

In relation to the concentrations of copper, and as discussed above for the human health risk assessment, the ANZG do not represent the concentrations of chemicals in water that aquatic ecosystems will be exposed to (they are not the exposure point concentrations). Hence, the next step in the HHERA is to apply the DAF relevant for the migration of chemical concentrations in leachate sourced from the waste RPM to groundwater or surface water. The DAF that has been adopted for this assessment is 20.

The revised guidelines for copper and aquatic ecosystems that can be derived based on the application of a DAF value of 20 are as follows:

- freshwater ecosystems (99% protection) – 0.006 mg/L
- marine ecosystems (99% protection) – 0.02 mg/L.

Maximum concentrations of leachable copper in the waste RPM are at or below the modified guidelines for the protection of aquatic ecosystems. The range of leachable copper concentrations in the waste RPM is <0.001 to 0.006 mg/L.

Hence, there are no other risk issues of concern for aquatic ecosystems and the use of waste RPM in recycled aggregates.

4.4 Uncertainties

4.4.1 Available data

The available data is for 100% waste RPM which provides a conservative evaluation where a small proportion of waste RPM is used in recycled aggregates (which is likely to be the case).

Low concentrations of barium, lead, nickel and zinc were detected in waste RPM, however, there is no ASLP data available.

Barium, lead and nickel concentrations were reported at or just above the LOR (in the range <1 to 2 mg/kg) which indicates that if these metals are present in the waste RPM, the reported concentrations are unlikely to be a human health or ecological risk issue. Concentrations of zinc were reported below the LOR in 2 samples of waste RPM with the sample from the Gold Coast reporting low concentrations of 13 mg/kg.

The reported lead, nickel and zinc concentrations are:

- below the ASC NEMP HIL-A values for a sensitive land use setting
- below the ASC NEMP ecological investigation levels (EILs) for areas of ecological significance (as well as the EILs for urban residential and public open space areas)
- within the Australian background ranges from the 1999 version of the ASC NEPM.

Concentrations of barium in waste RPM are well below the Canadian soil quality guideline for a residential/parkland setting of 500 mg/kg[3].

Concentrations of all 4 metals are below the thresholds for non-regulated waste (refer to **Section 2.2.3**).

Hence, the lack of ASLP analysis for barium, lead, nickel and zinc in waste RPM is not considered to be a significant data gap for this assessment.

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[3] Canadian Council of Ministers of the Environment | Le Conseil canadien des ministres de l'environment (ccme.ca)

4.4.2 ASLP test method

The data that has been used to assess potentially risks following the leaching and/or runoff of chemicals from waste RPM is from ASLP analysis. The ASLP analysis method is routinely used in Australia for estimating the potential for leaching from solids for all different types of contaminants. However, the ASLP testing protocol is also known to be a worst-case type of test as the procedure involves tumbling a 1:20 (solid:liquid) mix for 18 hours end on end (as per AS 1997). This is a large volume of water for a small amount of solid material, and the method also uses an extreme process for mixing the materials. This is very different to the way leaching will occur in the environment, when a small amount of water slowly permeates around a large volume of solid material.

In addition, the use of the ASLP results in this HHERA assumes that the following occurs in the environment:

- sufficient rain falls to saturate the aggregate containing waste RPM
- rain days are consecutive
- all rainwater infiltrates the aggregate profile:
    - there is no drying of aggregate in between rain days
    - there is no evaporation of water from the surface

This means that undertaking ASLP testing on waste RPM is expected to overestimate actual leachable concentrations, resulting in a conservative assessment.

4.4.3 Adopted screening level guidelines

The ADWG and ANZG adopted in this assessment are calculated based on conservative assumptions so that they are protective of potential exposures that may occur. For example:

- the ADWG are based on the consumption of 2 litres of water per day for a lifetime
- the availability of a reticulated water supply in Queensland means that the assumption that groundwater or surface water will be extracted and used for potable water supply is conservative
- where groundwater or surface water is used for recreational purposes, the adopted ADWG are conservative by 10 times (NHMRC 2008)
- where water is only extracted for non-potable water use (e.g. washing cars, irrigating gardens), the adopted ADWG are conservative by 100 times (NHMRC 2006).[4]
- the guidelines are chronic guidelines, that assume ongoing leaching of chemicals from waste RPM to the environment following its use.

4.4.4 Adopted DAF

The default DAF of 20 adopted for the transport of soil leachate to groundwater assumes that there is no adsorption in the unsaturated zone or aquifer (i.e. no retardation of movement through the aquifer by adsorption/desorption onto soil particles) and there is no degradation (chemical or

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[4] Based on the ingestion of 200 mL of water while swimming, and 5 to 20 mL during non-potable water use, as compared to 2 L/day for potable water use including drinking.

otherwise) in the waste RPM or water. The other assumptions used to derive the DAF of 20 are also conservative where:

- the source of the chemicals is infinite
- chemicals are present in the subsurface from the surface of the site through to the water table – i.e. the entire unsaturated zone is contaminated (note that road based is not expected to be in contact with the groundwater table; this would undermine the structural stability of the road)
- the receptor is at the edge of the source i.e. there is no dilution from recharge downgradient of the site
- the groundwater aquifer is unconfined, unconsolidated and homogeneous.

The DAF of 20 in combination with the use of ASLP analysis is expected to be highly conservative for metals, and also does not consider the concentrations of metals (including copper) that are commonly present in surface waterways in Queensland due to natural minerology.

In addition, the adopted approach does not include any consideration of the dilution that will occur with a surface water body, or for transport to surface water bodies that are not in close proximity to a re-use. This is particularly relevant for copper as the lowest screening level guideline for the protection of aquatic ecosystems is for the marine environment (99%) protection, and significant dilution will occur following the discharge of copper to the marine environment.

Where an additional DAF of 20 is adopted, to account for mixing into a small river or waterbody (Engelsen et al. 2012), the overall DAF for the use of aggregates with waste RPM is calculated as follows:

- default DAF = 20
- DAF for mixing in small waterway = 20
- overall DAF = 400.

The modified guideline for marine water with a 99% protection level is therefore 0.12 mg/L (0.0003 mg/L x 400 = 0.12 mg/L), which is 20 times higher than the maximum leachable copper concentration (0.006 mg/L). This is a high margin of safety.

4.5 Summary

Based on the assessment undertaken, there are no human health or ecological risk issues of concern associated with the presence of waste RPM in recycled aggregates.

4.6 Recommendations

The following is recommended based on the assessment presented in this section of the assessment:

1. Waste RPM are not suitable for use in recycled aggregates placed underneath buildings without further information or assessment.

Section 5. Conclusions

Environmental Risk Sciences Pty Ltd (enRiskS) has undertaken a technical review in relation to disposal and/or beneficial re-use of:

- waste created during the removal of raised pavement markers from roads (waste RPM)
- wash water derived from the use of line marking paint (wash water).

Both materials are currently disposed as regulated waste in Queensland. Waste RPM is disposed of as Category 1 regulated waste and wash water is disposed of as Category 2 regulated waste.

The review has addressed waste disposal and human health and environmental risk issues relevant to the disposal and/or re-use of the wastes based on information provided to 24 February 2023, and as described in this report. The review has not addressed any other waste materials or human health and environmental risks associated the generation of the waste products or other beneficial re-use scenarios. This review does not replace the environmental and/or occupational health and safety (OHS) procedures that are required for generation, handling and/or disposal of the wastes.

Based on the assessment and considering the identified uncertainties and subject to the recommendations provided in **Section 6**:

- waste RPM are categorised as Category 2 regulated waste
- wash water remains categorised as a Category 2 regulated waste due to the detection of PFAS, and based on reported concentrations of copper, zinc, EC and BOD
- risks to human health and the environment from the re-use of waste RPM as partial aggregate replacement in asphalt are low and acceptable to negligible
- there are no risks to human health the environment from the re-use of waste RPM in materials underlying asphalt (entombing the waste RPM, where a new asphalt road is laid over an older asphalt road with RPMs affixed) (the exposure pathway between the waste RPM and the environment is incomplete)
- risks to human health and the environment from the presence of waste RPM in recycled aggregates are low and acceptable.

Section 6. Recommendations

The following is recommended based on the assessment presented in this assessment:

6.1 Disposal of waste RPM

No recommendations.

6.2 Disposal of wash water

1. Request information on whether PFAS are present in the water-based paints used for line marking, including any laboratory analysis results to confirm presence/absence at the LOR that is possible for the waste (i.e. in consideration of matrix interference).

2. Confirm the wash water life cycle to determine the key stages where PFAS may be added to the wash water. i.e. which products are used in the process, where do these products come from and might they contain PFAS?

3. Review procedures at storage and handling sites to identify if there is the potential for environmental cross contamination.

4. Analyse samples of the products from the key lifecycle stages for PFAS.

6.3 Re-use of waste RPM for Applications 1 and 2

No recommendations.

6.4 Re-use of waste RPM in recycled aggregates

5. Waste RPM are not suitable for use in recycled aggregates placed underneath buildings without further information or assessment.

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Appendix A enRiskS Interim Technical Review

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18 September 2023

ARRB
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Attn: Robert Urquhart

Regulated waste interim technical review: reducing waste disposal from raised pavement markers and wash waters derived from line marking paint

1.0 Introduction and background

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by the Australian Road Research Board (ARRB), on behalf of the Queensland Department of Transport and Main Roads (TMR), to undertake a technical review and provide advice in relation to the disposal and/or beneficial re-use of:

- waste created during the removal of raised pavement markers from roads (waste RPM)
- wash water derived from the use of line marking paint (wash water).

Both materials are currently disposed as regulated waste in Queensland. Waste RPM are disposed of as Category 1 regulated waste under default waste categorisation item 59 - *tarry residues arising from refining, distillation or any other pyrolytic treatment* (DES 2022). Item 59 has been selected by ARRB as a bitumen adhesive is used to affix the RPM to the road, and a small amount of the adhesive as well as residual bitumen is unable to be removed from the waste RPM. Wash water is disposed of as Category 2 regulated waste under default waste categorisation item 70 - *waste from the manufacture, formulation or use of inks, dyes, pigments, paints, lacquers or varnish* (DES 2022).

Exhibit 1.1 shows photographs relevant to the wastes being reviewed.

Exhibit 1.1. Photographs (provided by ARRB) of wastes being reviewed in this letter comprising 1) waste generated following RPM removal, and 2) typical wash bay where line marking equipment is washed into a sump and pumped to holding tank for disposal.

ARRB has also requested advice on:

- available methods and/or treatment chemicals that would assist in separating solids from the wash water, for disposal and/or beneficial reuse
- information on the difference between line marking paint and architectural/decorative paint, noting that architectural/decorative paint is not classified as regulated waste in Queensland.

2.0 Objectives

The objectives of the technical review presented in this report are to:

- identify the key chemicals relevant to waste RPM from the categorisation thresholds for solid tested waste in Appendix 3 of DES (2022)
- identify any other key chemicals or analysis types relevant to the beneficial re-use of waste RPM
- identify the key chemicals relevant to the wash water from the categorisation thresholds for liquid tested waste in Appendix 4 of DES (2022)
- identify any other key chemicals or analysis types relevant to the beneficial re-use of wash water
- undertake a search of the scientific literature to source information on available methods and treatment chemicals that may assist in separating solids from the wash water
- undertake a search of the scientific literature to identify any published differences between line marking paint and architectural/decorative paint.

This assessment based on information provided by ARRB and available in the scientific literature to 14 October 2022, as relevant to the disposal and/or beneficial re-use of waste RPM and wash water. The review has considered human health and environmental risk issues associated with beneficial re-use. This assessment does not provide a revised waste categorisation for the above materials or address human health and environmental risks associated with the re-use of waste; these aspects are proposed to be addressed in a subsequent assessment when more information is available in relation to the presence of chemicals in waste RPM and wash water.

3.0 Key chemicals of relevance

3.1 Waste RPM

General

Information provided by ARRB indicates the following in relation to waste RPM:

- the RPM comprise a plastic body with a coated acrylic lens
- the bitumen adhesive comprises bitumen (petroleum) (25-40% by weight) and calcium carbonate (55-70% by weight) (this information is also shown on the safety data sheet [SDS] for the adhesive).

In relation to the bitumen adhesive, it is important to recognise that bitumen is used as a binder in asphalt (which is a mixture of sand, aggregate and bitumen) as well as concrete, and asphalt can also be used to seal pavements. The Queensland Government provides an End of Waste Code (EoWC) for Recycled Aggregates (ENEW7604819) (Queensland Government 2021) under the Waste Reduction and Recycling Act 2011. This includes the use of reclaimed asphalt pavements as a resource for engineering purposes in building, construction (which includes road and/or railway construction and maintenance) and/or landscaping applications. There are no guidelines for chemicals (including petroleum hydrocarbons) in the EoWC. There does not appear to be any difference in the use of bitumen as an adhesive for affixing RPM to a road and the use of bitumen in asphalt to construct a road. Hence, the EoWC for Recycled Aggregates appears applicable to waste RPM.

It is acknowledged that coal tar was historically used as a binder in asphalt (instead of bitumen), and there are human health and environmental risk issues associated with the presence of coal tar in the environment. However, coal tar is a different material to bitumen – coal tar is a type of creosote that is a by-product of the coal distillation process[1], and bitumen is a by-product of the crude oil distillation process.[2] Coal tar is not listed on the SDS for the bitumen adhesive.

Key chemicals of relevance

Given that bitumen is the key waste of interest in waste RPM, the key chemicals of relevance to waste RPM are petroleum hydrocarbons, specifically petroleum hydrocarbons in the C10 to C36 fraction including polycyclic aromatic hydrocarbons (PAH).

Elevated concentrations of petroleum hydrocarbons (C10-C36) may be present in the waste RPM, due to the presence of bitumen, other petroleum-based compounds or non-petroleum compounds. CRC CARE Technical Report No. 40, *Weathered Petroleum Hydrocarbons (Silica Gel Clean-Up)* (CRC CARE 2018), indicates that weathering processes can result in the formation of polar metabolite compounds (non-petroleum hydrocarbons) that are measured as total recoverable hydrocarbons (TRH) (i.e. petroleum hydrocarbons). Natural organic matter (NOM) may also be present and can contribute to the reported TRH concentration. This can make TRH based risk assessments difficult as it is often assumed that all the reported TRH is petroleum hydrocarbons when some or all of the reported concentration may be metabolites and/or NOM. Silica gel clean-up (SGC) analysis can be used to estimate the concentration of petroleum hydrocarbons versus polar metabolites and NOM in wastes, where the concentration following the SGC analysis is the concentration of petroleum hydrocarbons. Waste RPM are unlikely to contain NOM, however, may contain polar metabolites as a result of weathering. Given this, analysis of waste RPM for TRH following SGC is recommended.

Based on the information publicly available online, it is not possible to exclude the potential that bitumen may also contain metals (including nickel, copper, lead and vanadium) and a range of other aliphatic and aromatic hydrocarbons and phenols. While high concentrations of these chemicals are not expected to be present in waste RPM, analysis for these chemicals is recommended to confirm that they are not present at concentrations that would cause unacceptable human health or environmental risks following waste disposal or beneficial re-use. Similarly, pH analysis is recommended.

Analysis for leachable concentrations of some of the key chemicals (where this analysis is routinely undertaken in Australia) is recommended for any beneficial re-use assessment. Analysis for leachable concentrations should be undertaken using the Australian Standards Leaching Procedure (ASLP) at neutral (environmental) pH.

Table 3.1 summarises the key chemicals of relevance for waste RPM from Table 3a and Table 3b of Appendix 3 of DES (2022), and the recommended analysis for each key chemical.

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[1] Technical Direction 21 Coal Tar asphalt (nsw.gov.au)

[2] https://www.vivaenergy.com.au/blog/innovation/behind-the-bitumen

Table 3.1: Key chemicals of relevance – waste RPM (in order of priority)

Attribute or substance (item number from Appendix 3 of DES 2022)	Rationale	Analysis type	
		Total concentrations	Leachable concentrations (ASLP at neutral pH)
Petroleum hydrocarbons			
Petroleum hydrocarbons (C10 to C36) (38)	Main chemical in bitumen	✓	--
Silica gel clean-up (NA)		✓	--
Polycyclic aromatic hydrocarbons			
Benzo(a)pyrene (6)	Main chemical in bitumen	✓	✓
Polycyclic aromatic hydrocarbons (total) (42) [1]		✓	--
Petroleum hydrocarbons			
Petroleum hydrocarbons (C6 to C9) (37)	Bitumen contains other petroleum hydrocarbons	✓	--
Monocyclic aromatic hydrocarbons			
Benzene (5)	Bitumen contains other petroleum hydrocarbons	✓	✓
Toluene (54)		✓	✓
Ethylbenzene (25)		✓	✓
Xylenes (total) (57)		✓	✓
Styrene (vinyl benzene) (44)		✓	✓
Phenols			
Trichlorophenol (2,4,5-trichlorophenol) (52)	Bitumen may contain phenols	✓	✓
Trichlorophenol (2,4,6-trichlorophenol) (53)		✓	✓
Cresol (total) (15)		✓	✓
Phenols (total) (40)		✓	✓
Inorganic species			
Antimony (2)	Bitumen may contain metals	✓	✓
Arsenic (3)		✓	✓
Barium (4)		✓	✓
Beryllium (7)		✓	✓
Boron (8)		✓	✓
Cadmium (9)		✓	✓
Chromium (hexavalent) (13)		✓	✓
Copper (14)		✓	✓
Lead (27)		✓	✓
Mercury (28)		✓	✓
Molybdenum (30)		✓	✓
Nickel (31)	Bitumen may contain metals	✓	✓
Selenium (43)		✓	✓
Silver (45)		✓	✓
Vanadium (55)		✓	✓
Zinc (58)		✓	✓
Other			
pH (1)	Recommended for re-use assessment	✓	--

Notes:

“✓” = indicates analysis recommended.
“--” = indicates analysis not recommended.
NA = indicates not applicable.
1 = sum of acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenzo(ah)anthracene, fluoranthene, fluorene, indeno(a,2,3-cd)pyrene, naphthalene, phenathrene and pyrene.

Recommended analysis approach

The following approach is recommended for the analysis of waste RPM:

1. Provision of 3 x 1 kg samples of waste RPMs to Envirolab Services (Envirolab) for analysis i.e. plastic body plus bitumen plus adhesive and 1 kg of waste RPM from each of Rockhampton, the Gold Coast and Toowoomba. It is recommended that the samples encompass the amount of bitumen and adhesive that is usually present on waste RPM, and the age of the waste RPM, so an indication of variability can be obtained.
2. Analysis of 1 x 1 kg sample of waste RPM, with the most bitumen and adhesive, for the following (remaining 2 samples to be kept on hold by the laboratory):
    a) total concentrations of key chemicals listed in **Table 3.1**
    b) SGC.
3. Review of sample results by enRiskS to confirm that there is nothing unexpected that may impact on waste classification and beneficial re-use (e.g. significantly elevated concentrations of metals) and confirm which chemicals to analyse for ASLP (noting that ASLP analysis is not necessary where a key chemical is not detected in waste RPM above the laboratory limit of reporting).
4. Analysis of remaining 2 x 1 kg samples of waste RPM for:
    a) total concentrations of key chemicals listed in **Table 3.1**
    b) SGC.
5. Analysis of all 3 x 1 kg samples of waste RPMs for leachable concentrations of key chemicals listed in **Table 3.1**, and where the key chemical is detected in the waste RPM at steps 2a.

Steps 4 and 5 would be completed concurrently.

The above approach is suggested as the most cost-effective way to undertake the analysis, as it will identify any unexpected chemical concentrations early and also provide an opportunity to refine the analysis schedule where chemicals are not detected and unlikely to be present in the waste. However, this approach will also take the longest to obtain all of the sample results. Envirolab has indicated that they require 10 working days between sample receipt and the release of analysis results. Hence, the above approach would be expected to take up to 5 working weeks where 1 working week is allowed for enRiskS review at step 3. Where this timeline is not acceptable to ARRB, concurrent analysis of all 3 waste RPM for total and leachable concentrations of key chemicals, as well as SGC, is recommended. This may result in the generation of some data that is not useful for the assessment of waste disposal options or human health and environmental risks. However, results would be obtained within 2 working weeks.

3.2 Wash water

General

Information provided by ARRB indicates the following in relation to the wash water:

- the wash water is generated from the washing down of line marking spraying equipment and residual paint from 500 litre bladders and 20 litre buckets
- 2 types of water-based paint are used for line marking – Paint 1 and Paint 2
- the following ingredient is listed on the SDS for Paint 1:
    - ammonia (<0.2% by weight)
- the following ingredients are listed on the SDS for Paint 2:
    - acrylic polymer latex (10-30% by weight)
    - ammonium hydroxide (<0.1% by weight)
    - calcium carbonate (30-60% by weight)
    - 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate (<2% by weight)

  - titanium dioxide (1-10% by weight)
- minor amounts of an ammonia float solution is sprayed on the paint in the truck paint tank to stop the paint forming a skin
- the following ingredients are listed on the SDS for the ammonia float solution:
  - propylene glycol (10-30% by weight)
  - ammonium hydroxide (1-5% by weight)
  - water (>60% by weight).

Key chemicals of relevance

Based on the SDS for the paints used for line marking, the key chemical of relevance is ammonia. However, ammonia is volatile (as indicated on the SDS), hence, is not expected to be present at high concentrations in wash water. The other chemicals present in the paints or float solution comprise water, a polymer latex, calcium carbonate, propylene glycol, 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate and titanium dioxide. The polymer latex is the chemical that forms the paint and there are no human health or environmental risk issues of concern associated with the presence of water and calcium carbonate in wash water. Further discussion for propylene glycol, 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate and titanium dioxide is provided below.

Propylene glycol (1,2-propanediol; CAS Number: 57-55-6) is a synthetic liquid substance that absorbs water. This chemical is used in a range of applications, including to maintain moisture in certain medicines, cosmetics, or food products. It is listed as "*generally recognised as safe*" for use as an additive in food by the United States Food and Drug Administration (FDA)[3] and has been assessed to pose no unreasonable risk to human health and the environment by the Australian Industrial Chemicals Introduction Scheme (AICIS), based on its use in cosmetics and release to sewer respectively[4]. Hence, there are no human health or environmental risk issues of concern associated with the presence of propylene glycol in wash water.

2,2,4-Trimethyl-1,3-pentanediol monoisobutyrate (TMPD-MIB, texanol; CAS Number: 25265-77-4) is a volatile organic compound (VOC) found in paints and printing inks, where it is used as a coalescing agent. This chemical floats on water, has been reported in polypropylene packed food samples and may also be used to prepare carbon nanotube paste.[5,6] The AICIS has concluded that this chemical poses no unreasonable health risks based on its use in cosmetics. Hence, there are no human health risk issues of concern associated with the presence of 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate in wash water. The European Chemicals Agency (ECHA) indicates that this chemical is used in coating products, polishes and waxes, washing and cleaning products, biocides (e.g. disinfectants, pest control products), plant protection products, adhesives and sealants. It is also indicated that this chemical is readily biodegradable in freshwater and is not considered a chemical of concern for the environment.[7] Hence, there are no environmental risk issues of concern associated with the presence of 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate in wash water.

Titanium dioxide (CAS Number: 13463-67-7) is a naturally occurring oxide with a wide range of applications including in paints, fillers, adhesives, food and cosmetic/sunscreen colours.[8,9] The AICIS has concluded that this chemical poses no unreasonable risk to the environment based on its direct release to surface waters or

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[3] Propylene Glycol | Public Health Statement | ATSDR (cdc.gov)
[4] https://services.industrialchemicals.gov.au/search-assessments/
[5] 2,2,4-Trimethyl-1,3-pentanediol monoisobutyrate mixture of isomers, 99 25265-77-4 (sigmaaldrich.com)
[6] https://pubchem.ncbi.nlm.nih.gov/compound/6490
[7] Registration Dossier - ECHA (europa.eu)
[8] https://pubchem.ncbi.nlm.nih.gov/compound/26042
[9] https://www.industrialchemicals.gov.au/sites/default/files/Titanium%20dioxide_Human%20health%20tier%20II%20assessment.pdf

soil. AICIS has also assessed the potential risks to human health from this chemical, where it is indicated that titanium dioxide can be considered non-hazardous as it[10]:

- has a low water solubility and is therefore expected to have a low bioavailability for all routes of exposure
- has a low short-term (acute) oral and inhalation toxicity and is insoluble, so is not expected to sufficiently penetrate through the skin to cause system toxicity effects
- is not expected to be irrigating to the skin or eyes, or sensitising to the skin
- has been used in sunscreens at high concentrations over a long time period with no reports of skin irritation
- is not expected to cause serious damage to health following long-term (chronic) oral exposure
- is not considered carcinogenic
- is not expected to have reproductive or developmental toxicity
- may increase respiratory sensitisation to other allergens, particularly where nanoparticles are present, and serious damage to health following repeated inhalation exposure[11], however, effects may not be specific to this chemical.

Hence, there are no human health or environmental risk issues of concern associated with the presence of titanium dioxide in wash water.

In relation to other chemicals that may be present in the wash water (but not identified on the SDSs for the paints), water-based paints were reportedly developed by the paint industry to reduce the use of solvents and metals in paints, following reports of adverse health effects to painters from earlier paints. These water-based paints comprise emulsions of pigments and polymers in water, with smaller amount of solvents and additives such as biocides, surfactants, pigments, binders, amines and monomers (Wieslander, Norback & Edling 1994). The basic chemical components of paints can vary widely, depending on the required properties of the paint. The main organic solvents used in paints are toluene, xylene, aliphatic hydrocarbons, ketones, alcohols, esters and glycol ethers. Other chemicals that are listed as potentially present in water based paints are amines, ammonia, amides, formaldehyde, ethylene glycol, mercury compounds, methyl cellulose, phenols and chlorinated compounds (IARC 2012).

Based on the above, all chemicals listed in Table 4a and Table 4b of Appendix 4 of DES (2022) are identified as key chemicals for this assessment, except for:

- peroxides (item 5)
- asbestos (item 6)
- fluoride (item 26)
- polycyclic aromatic hydrocarbons (PAH) (items 6 and 42)
- dinitrotoluene (item 24)
- specific persistent organic pollutants (POPs) (items 22, 1, 33, 34, 41 and 36).

It is recommended that per-and poly-fluoroalkyl substances (PFAS) (POPs item 5) be included as key chemicals as PFAS are listed in Appendix B of the PFAS National Environmental Management Plan (NEPM) (HEPA 2020) (activities associated with PFAS contamination) in Table B2 under “*Construction industry (Tile coatings, stone coatings, paints, varnishes, sealants, other architectural coatings for films, facades and infrastructure, rigid foams, silicone rubber, thread sealant tapes and pastes and PPE)*”.

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[10] https://www.industrialchemicals.gov.au/sites/default/files/Titanium%20dioxide_Human%20health%20tier%20II%20assessment.pdf

[11] Adverse health effects can be expected when this chemical is inhaled in large quantities for long periods of time, due to lung overload.

Analysis for PFAS Total Oxidisable Precursor Analysis (TOP Assay) is recommended, as per the requirements of DES (2022). i.e.

> *"As PFAS are a broad class of substances and laboratory standards are not available for every potential PFAS compound, testing must include standard analysis for easily identifiable PFAS and additional testing that shows presence/absence of other PFAS, namely the total oxidisable precursor assay (TOP assay) mentioned in the PFAS National Environmental Management Plan or an equivalently accurate detection method."*

Analysis for ammonia is recommended due to the use of the ammonia float solution.

Analysis for biological oxygen demand (BOD), chemical oxygen demand (COD) and suspended solids (SS) is recommended in case disposal to trade waste is an option.

Recommended analysis approach

The following is analysis approach is recommended for the wash water consistent with the analysis approach recommended in **Section 3.1:**

1. Provision of 3 samples of wash water to Envirolab for analysis. It is recommended that the 3 samples encompass the amount of paint that is usually present in the wash water, and the age of the wash water that requires disposal/re-use, so an indication of variability can be obtained.
2. Analysis of 1 sample of wash water, with the most paint, for the following (remaining 2 samples to be kept on hold by the laboratory):
   a) concentrations of key chemicals in Table 4a and Table 4b of Appendix 4 of DES (2022) excluding those listed above
   b) PFAS Total Oxidisable Precursor Assay (TOP Assay)
   c) Ammonia
   d) COD and SS (note, BOD is already included as it is listed in Table 4a of DES 2022)
3. Review of sample results by enRiskS to confirm that there is nothing unexpected (e.g. significantly elevated concentrations of metal/s).
4. Analysis of remaining 2 samples of wash water for:
   a) concentrations of key chemicals (as per Step 2a)
   b) PFAS TOP Assay
   c) Ammonia
   d) COD and SS.

The above approach would be expected to take up to 5 working weeks where 1 working week is allowed for enRiskS review at step 3. Where this timeline is not acceptable to ARRB, concurrent analysis of all 3 wash water samples for the key chemicals and TOP Assay. This may result in the generation of some data that is not of use for waste classification, however, results would be expected within 2 working weeks.

3.3 Uncertainties

Where chemicals from Appendices 3 and 4 of DES (2022) are not included in the recommended analysis schedule, this is because they are not expected to be present in waste RPM and wash water based on enRiskS' experience and available information (as outlined above). To support this conclusion, an additional literature search was undertaken on 11 October 2022 using Google Scholar and ScienceDirect to specifically search for literature indicating the presence of other key chemicals in waste RPM and wash water. This search did not identify any additional key chemicals for the purpose of the assessment.

It is also noted that the identification of some chemicals in the DES (2022) lists as key chemicals is conservative e.g. the inclusion of PFAS and cyanide for wash water, all metals for both waste RPM and wash water, and other petroleum hydrocarbons and phenols for waste RPM. The chemicals have been identified as key chemicals for completeness and the avoidance of doubt.

4.0 Available methods to separate solids from paint

4.1 General

In this section of the assessment a search of the online scientific literature was undertaken to source information on available methods and treatment chemicals that may assist in separating solids (including paint) from the wash water. The literature search was undertaken on 11 October 2022 using Google Scholar and ScienceDirect.

The literature search identified 3 main methods that could be used to separate solids from the wash water – membranes, coagulants and flocculants, and nanotechnology. Further discussion is provided below.

A copy of the 1 of the key papers that may be of interest to ARRB is provided in **Attachment A**. If one of the below 3 methods and/or a particular study is of interest to ARBB it may also be possible to refine the literature search determine if more specific information is available.

4.2 Nanotechnology

Nanotechnology is identified as a way of converting harmful dyes (which have a low solubility and high stability) to less harmful by-products through photocatalytic processes (Hashmi et al. 2021). Relevant nanoparticles comprise silver, gold, zinc oxide, copper oxide and titanium dioxide. While some promising results were identified using these nanoparticles, the authors also identify the potential for residual toxic effects from the nanoparticles, and that it may be difficult to scale up the technology to an industrial level.

An older review is also available outlining the use of nanoclays/organoclays (organically modified layered silicates) for waste water treatment, where the clays are used in combination with other sorbents (such as activated carbon and alum) or technologies (such as reverse osmosis) (Patel et. al. 2005). The authors note that organoclays have been proven to be superior to any other water treatment technology where the waste water contains substantial amounts of oil and grease or humic acid. In the case of oil and grease, this is effectively because organoclays comprise alternating organic (or hydrophobic) and inorganic layers, and organic substances (such as oils) can partition from water onto this hydrophobic layer.

4.3 Membranes

Membranes are used for waste water treatment in the food industry, to aid in separating substances and clean water in chemically unchanged forms, to allow recycling and/or minimise waste disposal costs (Muro, Riera & Díaz-Nava 2012). It is noted that waste water from the food industry does not normally contain toxic compounds (except where pesticides are present from washing fruits/vegetables). However, waste from this industry often has a high biological oxygen demand (BOD), chemical oxygen demand (COD) and total dissolved solids (TDS) content (due to the presence of proteins, fats, additives, dyes etc.). The authors note that:

- most commercial membranes are made of organic polymers (polysulfones and polyamides) and inorganic materials (ceramic membranes based on oxides of zirconium, titanium, silicium and aluminium)
- the 4 main membrane configurations used by the industry are plate-and-frame, spiral wound, tubular and hollow-fiber
- the choice of membrane system is usually determined by factors such as cost, risks of plugging of the membranes, packing density and cleaning opportunities

- the 4 main membrane processes used by the industry are microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO)
- the choice of membrane process is usually determined by particle size and the chemical nature of the species requiring separation.
- pre-treatments include pH adjustment, thermal treatment, addition of chemicals and pre-filtration, where:
  - pH adjustment and thermal treatment can decrease precipitation effects
  - the addition of chemicals can increase the particle size through aggregation, micellation or complexation

This paper specifically lists the NF and UF membrane processes for use in separating pigments. MF membrane processes are also identified for the removal of suspended solids.

The use of membranes for treating water and waste water is also the subject of a recent editorial (Giacobbo & Bernardes 2022), where it is identified that membrane separation processes (MSPs) have gained prominence due to their inherently low energy requirements, mild operating conditions, separation efficiency, ease of scaling up, lack of additives and the possibility of obtaining high-quality water (which can be re-used). The editorial considers the findings from 6 research articles which outline:

- the use of a cementitious microfiltration membrane (CM) with a catalytic ozone oxidation function for the removal of organic pollutants
- the combination of coagulation and ultrafiltration (UF) membrane rotation on membrane fouling control
- the effect of membrane molecular weight cut-off, transmembrane pressure, temperature and cross flow velocity for 4 different membranes used for the ultrafiltration of anaerobic digestate from swine manure
- the use of a hydrocyclone with a porous membrane wall for separating a water-oil mixture
- the effect of pH on the removal of a pharmaceutical chemical by nanofiltration with 2 commercial membranes
- the ecology and carbon footprint in a reverse osmosis sea water desalinisation plant in Spain.

4.4 Coagulants and flocculants

The use of coagulants and flocculants is identified in the scientific literature as a common and efficient method for separating paint (or other substances) from waste water. In this context and in simple terms, coagulation is the process of neutralising all the negative charges in water. This allows flocculation, which is the process where contaminants to absorb to each other. Larger particles form and settle to the bottom to be removed by sedimentation, filtration or flotation.

One study outlines the treatment of wash water from paint spray booths using chemical coagulation followed by suspended solids separation using the following (Sokolović & Sokolovic 1996):

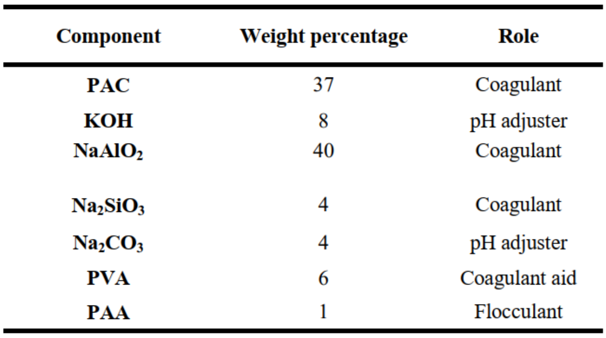
- aluminium sulphate as the coagulant (optimum dose 160 to 180 mg/L)
- polyacrylamide as the flocculant (optimum dose of 1 to 1.5 mg/L)
- domestic bauxite, perlite, zeolite and activated carbon as absorbents
- expanded polystyrene granules as packing material in the reactor and deep bed filter.

Total treatment efficiency using all processes was in the range 66 to 86%, based on COD concentrations.

Iron separation, surface charge and size are identified as important factors for coagulant-flocculant processes (Rahbar et. al. 2013). The choice of coagulant is also important as the coagulant may modify other properties of the waste water such as conductivity (Bouranene et al. 2015).

Bouranene et. al. (2015) reviews the effectiveness of iron based coagulants (ferrous sulphate, ferric sulphate and ferric chloride) on the treatment of waste water from the preparation of water based paints (blanroc super[12]). The effect of pH was also investigated. The authors found that pH played a significant role in the coagulation-flocculation process. Treatment was most effective when the pH was adjusted to 2.5 units before adding the coagulant, and then a base was added to increase the pH to 7 to 8 units. Treatment efficiency varied depending on the coagulant used and the blanroc super concentration.

The effect of pH on coagulation and flocculation processes in paint waste water was also investigated by Rahbar et. al. (2013), where a pH range of 9.5 to 10.5 units was found to be most effective i.e. maximum paint removal, of up to 95%, was obtained in this pH range. This was due to the increase in aluminium hydroxide ions and solid content removal with increasing pH. The composition of the flocculant-coagulant compound used in this study is shown in **Exhibit 4.1**. A copy of Rahbar et. al. (2013), with the full details of the experimental methodology, is provided in **Attachment A**.



Component	Weight percentage	Role
PAC	37	Coagulant
KOH	8	pH adjuster
$NaAlO_2$	40	Coagulant
Na_2SiO_3	4	Coagulant
Na_2CO_3	4	pH adjuster
PVA	6	Coagulant aid
PAA	1	Flocculant

Exhibit 4.1. Composition of flocculant-coagulant compound investigated by Rahbar et. al. (2013).

Other studies (Aboulhassan et. al. 2014; da Silva et al. 2016; Kulkarni 2017) note that while coagulation-flocculation processes are widely used and simple to operate, overall performance may still be poor and further treatment may be required to reduce colour, organic loading and odour.

Aboulhassan et. al. (2014) pre-treated waste water from paint manufacturing with the flocculant ion chloride and the anionic polyelectrolyte Chemic 5161. Batch aerobic biological treatment was then undertaken in an aeration tank (a 2 litre tank with a magnetic stirrer and aeration via pumps and diffusers). An activated sludge culture was obtained from a municipal biological waste water treatment plant and cultivated in diluted waste water prior to addition to the aeration tank. This resulted in the generation of a clear effluent with 97% colour removal. The removal efficiency for COD and BOD was 96% and 92.5% respectively.

da Silva et. al. (2016) investigated the treatment of waste water from water based acrylic paint manufacturing using the coagulant aluminium sulfate with electrochemical methods (boron-doped diamond [BDD] electrode). Electrochemical methods transform organic compounds into biodegradable substances which are eventually converted to carbon dioxide and water. The authors found that while the use of aluminium sulfate alone (at a dosage of 12 mL/L) was effective at treating the waste water, the use of electrochemistry was required to treat the water to the standard required for discharge into water bodies.

4.5 Other methods

Kulkarni (2017) identifies the following additional methods for the treatment of waste water from the paint industry (either alone or in combination with other methods):

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[12] Blanroc super is a white substance in emulsion form that is used to form paint, comprising 12% by weight polyvinyl acetate (PVA), 45.5% by weight calcium carbonate, 4% by weight titanium dioxide and 35.5% by weight water.

- advanced oxidation using Fenton reagents and hydrogen peroxide
- cactus enzymatic system and cactus biopolymer sludge treatment
- photochemical
- ion exchange
- radiation.

The use of lignin for the treatment of waste water containing heavy metal ions, inorganic anions, organic dyes and drugs has also been reviewed (Wang et al. 2022). Lignin a naturally synthesised polymer found in plant cell walls that has potential applications as a readily available and low cost absorbent.

5.0 Industrial versus architectural/decorative paint

A search of publicly available online information as part of this assessment did not identify any clear reasons why regulated waste in Queensland (and in other states such as Victoria) includes industrial paint but not architectural/decorative paint. Possible reasons include:

- industrial paints may be produced and/or used in larger volumes
- industrial paints may contain different chemicals to architectural/decorative paints (e.g. metals or higher concentrations of solvents) as they are developed for specialist applications
- industrial paints may be used with other additives.

It is also noted that Australia has a program called Paintback which is industry-led and has been operational in Australia since 2016. This program provides a way for the general public (households) to easily dispose of up to 100 litres in volume (per visit) of architectural/decorative paint and packaging. It is funded through a levy of 15 cents (plus GST) per litre applied to the wholesale price of eligible products. This funding is used for research and development activities that aim to improve resource recovery and divert waste paint away from landfill. Aerosol paints, industrial surface and maintenance coatings and additives are not accepted by Paintback.

One way to compare the difference between architectural/decorative and industrial paints is to compare the information on the SDS for an example of both paint types from the same supplier. SDS for an architectural/decorative (interior) paint and an industrial (line marking) paint from the same Australian supplier were reviewed as part of this assessment. Both SDS are marked “Non-Hazardous Chemical” and “Non-Dangerous Goods”, and 100% of the listed ingredients for both products are determined to be non-hazardous. The listed measures for first aid, firefighting, accidental release, handling and storage and exposure controls/personal protection are identical between both SDS. Similarly, there are no differences in the listed information for stability and reactivity, toxicology, ecology, disposal and transport. The line marking paint is listed as having a mild ammonia odour and the odour of the interior paint is listed as “mild characteristic”.

Paintback describes paint as a “high volume low toxicity product”. Based on the above SDS, both the interior paint and the line marking paint are low toxicity products.

To confirm whether there are any significant differences in the chemicals and concentrations in interior paint as compared to line marking paint, the recommended analysis approach outlined in **Section 3.2** could be applied to both paints. There are many paints that could be selected for this analysis and the selection of 2 different water-based interior paints is recommended to provide an idea of variability. Line marking paints selected for investigation should have similar ingredients to those of Paint 1 and Paint 2 that were investigated as part of this review.

6.0 Conclusions

This review has identified the key chemicals in waste RPM and wash as relevant to waste disposal and beneficial re-use of these materials. The identified key chemicals are outlined in **Section 3.1** (waste RPM) and **Section 3.2** (wash water), along with a recommended analysis approach.

There are 3 main methods that could be used to separate solids from the wash water – the use of membranes, coagulants and flocculants, and nanotechnology. A copy of the one of the key papers that may be of interest to ARRB is provided in **Attachment A**. If one of the above 3 methods and/or a particular study is of interest to ARBB it may also be possible to refine the literature search determine if more specific information is available.

In relation to the differences between architectural/decorative and industrial paint, this review has not identified any clear reasons why regulated waste in Queensland (and in other states such as Victoria) includes industrial paint but not architectural/decorative paint. Possible reasons include:

- industrial paints may be produced and/or used in larger volumes
- industrial paints may contain different chemicals to architectural/decorative paints (e.g. metals or higher concentrations of solvents) as they are developed for specialist applications
- industrial paints may be used with other additives.

It is also noted that Australia has a program called Paintback which is industry-led and has been operational in Australia since 2016. Aerosol paints, industrial surface and maintenance coatings and additives are not accepted by Paintback.

To confirm whether there are any significant differences in the chemicals and concentrations in architectural/decorative paint as compared to line marking paint, the analysis approach outlined in **Section 3.2** could be applied to architectural/decorative paint and industrial paint manufactured by the same supplier. The analysis of 2 different water-based architectural/decorative paints is recommended (there are many paints that could be selected for this analysis). Line marking paints selected for investigation should have similar ingredients to those of Paint 1 and Paint 2 that were investigated as part of this review.

7.0 Limitations

Environmental Risk Sciences Pty Ltd has prepared this report for the use of ARRB and TMR in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in this report.

The methodology adopted and sources of information used are outlined in this report. Environmental Risk Sciences Pty Ltd has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

This report was prepared in October 2022, and updated in September 2023, and is based on the information provided and reviewed at that time. Environmental Risk Sciences Pty Ltd disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Yours sincerely,

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Attachment A Rahbar et. al. (2013)


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Journal of Chemical Health Risks

Journal of Chemical Health Risks (2014), 4(1), 37– 43

ORIGINAL ARTICLE

Effect of pH on Separation of Solid Content from Paint Contained Wastewater by a Coagulant-flocculant Compound

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KEYWORDS

Coagulant
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ABSTRACT: Chemical wastewater treatment is one of the attracting and common methods for wastewater treatment among the currently employed chemical unit processes. The use of coagulant-flocculant compound is one of the efficient methods for separating of paint and recovery of water. In this research, it was introduced and the effect of pH on removal of solid content from solution was studied experimentally. For this purpose, sludge and suspended solid content of the solution were determined in a jar test by measurement of UV absorption of treated solution and solid separation percentage. The results showed that in pH range 9.5-10.5, maximum efficiency of solid content removal was up to 95%. Consequently, maximum paint removal was obtained in this range of pH. The separation of solid content of the solution was due to formation of aluminum hydroxide. As shown by the results, the reduction of potassium hydroxide as pH adjuster caused decrease of pH and consequently decrease of aluminum hydroxide and solid content removal.

INTRODUCTION

In chemical industries, organic compounds are the most pollutants of effluent in water. The basis of water treatment process is separating solid-liquid phase. This process accomplish with chemical materials and special equipments. The high purity water can be achieved by this type of process and it can reuse in various industries. Flocculants and coagulants are used in suspending and coagulating process for separating of solid phase which exists as a suspension in a liquid. For ion separation, size and surface charge are two significant factors which play a vital role in coagulation-flocculation processes [1]. Coagulation is a process which neutralizes all negative charges of water and accordingly contaminations absorb each other. The use of polymeric Aluminum compound as a flocculant agent is more common these days. Poly Aluminum Chloride

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(PAC) and Poly Aluminum Phosphate are two clear-cut examples of mentioned compound.

Note that PAC application is more popular than other compounds. These kinds of coagulants efficiently act in a low temperature and wide range of pH. Polymeric coagulants usually have high charge density and chain length. They can surround the color by their metallic elements like Aluminum, Iron and Silicon. Through this process, the color is neutralized and removed [2, 3].

Aluminum sulphate is an example of flocculants that could bond with Sodium Hydrogen Carbonate or Potassium Hydroxide and they are formed insoluble metallic Hydroxides such as Aluminum Hydroxide and Iron Hydroxide. Generally, Hydroxides which are water-insoluble have such a low solubility and cause of polymeric and viscous form of water [4].

The coagulation of colloidal ions were examined in solutions which contain Humic acid/Aluminum sulphate solution at pH in range 4-10 and Aluminum sulphate (3-1000 µM Al). They studied the effects of colloidal ions with analyzing colloid surface change and UV absorbance of solution. The obtained results showed the appropriate performance range of coagulation (pH solution and quantity of Al) and the mechanism of coagulation [5].

In an *invitro* study, the effects of three organic coagulants were presented on decrease of discharge effluent turbidity in an industrial unitare. These coagulants consist of Aluminum sulphate, Ferric chloride II and Poly Aluminum chloride which optimum dosage and pH of each ones are determined. In the case of applying 20 mg/L of PAC at pH=6, optimum efficiency of decreasing wastewater turbidity are reached, although the maximum turbidity decrease up to 90% could be achieved by applying 50 mg/L of PAC at pH=6 [6].

The effects of pH, Aluminum and Iron concentration were studied on color removal from effluentsare. They presented the effects of those factors on amount of sedimentation in different Aluminum Hydroxide Compounds which form in accordance with correspondent reactions [7].

In an *in vitro* investigation, a novel formulation of Poly Aluminum chloride and Potassium hydroxide along with other materials as pH adjuster and coagulant aid was introduced which increases the amounts of solid content removal to 96% [8].

The Polymeric chloride – Poly-epichlorohydrin-dimethylamine (PFC-ECH-DAM) composite flocculants with different OH/Fe ratios, Fe to organic ECH-DAM mass ratios and cross-linker types were comparatively investigated in terms of formed floc aggregation process and floc characteristics for the treatment of synthetic dyeing wastewater. The results demonstrated that the synergic effect of PFC with ECH-DAM promoted the formation of larger flocs with higher growth rate and wider distribution of floc sizes. During the coagulation of reactive red (K-2BP) dyeing wastewater, strengthened floc properties can be obtained at higher flocculant dosage ranges (>80 mg/L) and solution pH of about 7.5 [9].

Five novel coagulants, DC-491, Fennofix K97, BWD-01, MD-03 and MD-04 were chosen to treat reactive brilliant red X-3B simulated wastewater by jar tests. The results showed that the decolorization efficiencies were all higher than 75% at initial pH 8.2 and temperature 20 after 20 minutes of reaction. Then, two typical coagulants, BWD-01 and MD-04 which had better performance were chosen to study the effect of dye removal of X-3B at different operating parameters, including coagulant dosage, pH, and sedimentation time and reaction temperature of simulated wastewater. Decolorization efficiency of MD-04 for X-3B solution was higher than 80% in pH range from 3 to 9, while for

BWD-01, efficiency increased from 37.3% to 82.3% in this pH range [10].

Several options of decolorization of textile wastewater by chemical means have been reviewed. Based on this review, some novel pre-hydrolyzed coagulants such as Polyaluminium chloride (PACl), Polyaluminium ferric chloride (PAFCl), Polyferrous sulphate (PFS) and Polyferric chloride (PFCl) have been found to be more effective and suggested for decolorization of the textile wastewater. Moreover, use of natural coagulants for textile wastewater treatment has also been emphasized and encouraged as the viable alternative because of their eco-friendly nature [11].

The coagulation–flocculation treatment using $FeSO_4·7H_2O$ as a coagulant was evaluated for the removal of organic compounds and color from synthetic effluents simulating the cotton, acrylic and polyester dyeing wastewaters. The obtained results showed that the optimal operating conditions were different for each effluent, and the process (coagulation–flocculation) as a whole was efficient in terms of color removal (~91% for cotton, ~94% for acrylic effluents; polyester effluent is practically colorless) [12].

The coagulation–flocculation process was studied to find out the performance of different coagulants and flocculants like alum, ferric chloride, Aluminium chloride, ferrous sulphate, poly Aluminium chloride (PAC), cationic and anionic Polyacrylamide polymers in individual form as well as in different combinations. The effects of dosing rate, settling time and pH were examined for reduction of COD, TSS and color. Coagulants used in combinations were found to be more effective in reducing COD, TSS and color instead of using individual form. The initial pH of the effluent for coagulation process was found to have remarkable effect on COD, TSS and color removal. The most effective results were found using cationic and anionic Polyacrylamide combination with ferric chloride and Aluminium chloride and reduction of 76% COD, 95% TSS and 95% color were observed at pH < 3 [13].

In this investigation, the effects of pH solution were experimentally examined on performance of color removal by coagulation–flocculationprocess. For this purpose, a new coagulant-flocculant compound was applied in the form of solid powder [14].

MATERIALS AND METHODS

Materials

The Sample: For preparing the sample, a kind of alkyd paint (vehicle color paint-Hadi's brand) was dissolved in water such a way that the concentration of color in water equals 5gr/L. This concentration of color was chosen according to presented information by PPG (Italy) and BASF (Germany) companies about concentration of colors in effluent of automotive factories [15, 16].

Flocculant-Coagulant Materials

The new flocculant-coagulant compoundis were used to investigate the role of pH. This powdery substance contained the following composition that each of them played a role in the flocculation-coagulation process. The role of each component in flocculant-coagulant composition shows in Table 1.

Table 1. Composition of flocculant-coagulant powder [8]

Component	Weight percentage	Role
PAC	37	Coagulant
KOH	8	pH adjuster
$NaAlO_2$	40	Coagulant
Na_2SiO_3	4	Coagulant
Na_2CO_3	4	pH adjuster
PVA	6	Coagulant aid
PAA	1	Flocculant

Experimental

A mixer model RW20-n fabricated by IKA company was used for mixing coagulant-flocculant powder of sample. Its characteristics are listed in Table 2.

Table 2. Specifications of the mixer

Impeller Type	No. of Impeller	Impeller Dia.(mm)	Shaft Length(mm)	Shaft Dia.(mm)	Max. Speed(rpm)
Propeller	4	50	350	8	2000

UV Spectrophotometer model Ikon was supplied by Biotek-Kontron company which has one Tungsten lamp (for visible light) and one Deuterium lamp (for UV ray) was applied to determine the UV absorption. pH meter model RL-150 made by Russel company(England) was used to determine the quantity of solution pH.

Experimental procedure

A jar test was performed as one liter of the sample was poured into the mixer and mixed with 400 rpm speed. One gram of coagulant-flocculant powder was added during the mixing and mixing was continued within 1.5 minutes upon coagulating phenomena was completed. Then, mixing was implemented with 200 rpm speed within 15 minutes in order to flocculate the paint. For floating flocculated paint on the water, the solution was released within 2 hours. The paint which was turned into sludge was removed by filter Paper. pH of solution was changed by changing the quantity of Potassium Hydroxide. The operation was carried out in ambient temperature. The condition of the performed test shows in Table 3.

Table 3. The condition of the performed test

Coagulation Time(sec)	Coagulation Speed(rpm)	Focculation Time(sec)	Flocculation Speed(rpm)	Settling Time(hr)	Solution pH
90	400	900	200	2	8.5-10

Method of estimation of solid content removal

Presented method by PPG (Italy) and BASF (Germany) was applied to calculate the amount of solid content removal (paint plus coagulant-flocculant compound) which are suspended as a sludge in the solution such a way that sludge was separated from solution by paper filter[14, 15]. Then, the sludge was put on a watch glass and placed in oven with 105^{o}C within 2 hours until water was taken. If (a) shows the amount of remained solid after separation of water from the sludge and (b) shows the amount of coagulation-flocculation compound which was used, then color separation percentage was obtained by following equation. It should be noted that total amount of solid in the solution is flocculant-coagulant powder plus dissolved paint.

(I) ***a*** = Weight of solid content in the dry sludge (removed paintand coagulant-flocculant powder)

(II) ***b*** **=** Weight of remained (suspended) solid in the solution after coagulation-flocculation treatment

(III) ***c*****=** Initial total weight of solid in the solution **=** ***a*** **+** ***b***

(IV) Separation percentage of solid content $=(\frac{a}{c})\times 100$

(V) Suspended solid content percentage

$$= \left(\frac{b}{c}\right) \times 100$$

RESULTS AND DISCUSSION

The variation of removed solid versus pH of solution is demonstrated in Figure (1). As it can be seen, due to increase of pH and alkalinity of solution, the amount of removed solid has been increased. Also, the most amount of solid has been separated when pH varied in range of 9.5-10.5. According to equation **IV** and considering that ***c*** is constant, increase of ***a*** (parameter of equation **I**) decreased band solution has the minimum amount of suspended solid when pH was in this range, as shown in Figure (2). Solid removal percentages in different pH are presented in Figure (3) which shows that maximum separation was achieved when pH varied in range of 9.5-10.5. Also, the results showed that in this range of pH, the minimum amount of solid spills existed in the remained solution and consequently, the minimum UV absorption of solution was obtained (Figure 4). For describing the phenomena, it should be mentioned that, the main coagulant agents in coagulant-flocculant composition contains *Al* ions, that surround color powder and neutralize them as it is illustrated in Figures (5) and (6). Furthermore, the alkaline pH of the solution, between 9.5-10.5, caused to release enough amount of OHions in solution which increased the intensity of reaction in order to produce aluminum hydroxide and consequently, to increase coagulation of paint ions and separating them. If pH of solution was decreased lower than the mentioned range (by decreasing potassium hydroxide which controls pH value), the intensity of reaction for production of aluminum hydroxide would decrease and, as a result, the required coagulating of solution for paint removal did not occur and this phenomena led to reduce the rate of paint removal. If pH solution increased more than 10.5, the extra amount of OH ions would remain in solution which caused the following reaction improved on the contrary way and reduced the quantity of Al ions thus lower amount of paint ions was coagulated in solution.

CONCLUSION

In this study, effects of pH on removal of solid content from painted wastewater were examined with a novel coagulant-flocculant composition. Experimental results showed that, as pH solution was closer to 10.5 and solution was more alkaline, amount of OH ions increased and coagulation of paint ions were improved. The increase of coagulation of paint ions caused increase of solid separation in sludge form and therefore, amount of suspended solid were reduced in the solution. Moreover, decrease of solution alkalinity (by decreasing of amount of potassium hydroxide formation) led to form the lower amount of Al $(OH)_3$ and consequently, coagulation and solid removal were decreased.

$$Al(OH)_3 \rightleftarrows Al^{3+} + 3OH^-$$

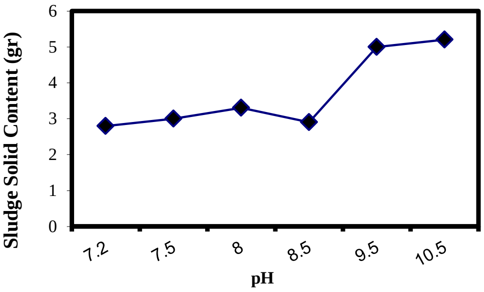

Figure1. Variation of separated solid as sludge in different pH

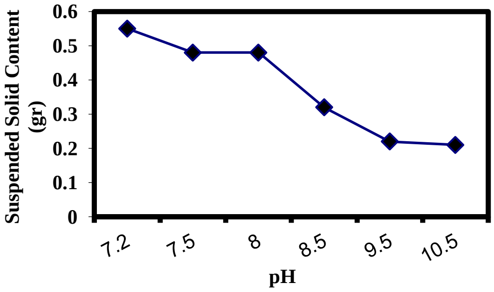

Figure 2. Variation of remaining suspended solid in solution in differentpH

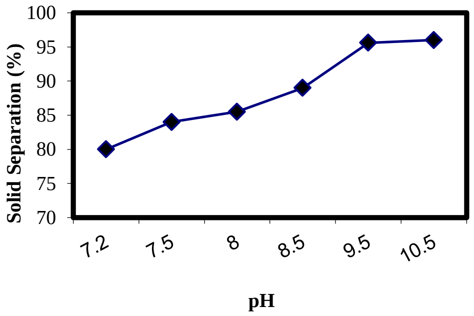

Figure 3. Variation of color solid separation percentage in different pH

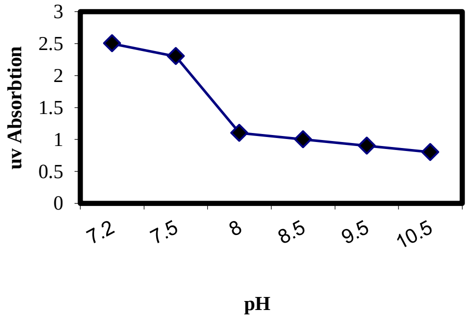

Figure 4. The absorption of solution after solid separation in different pH

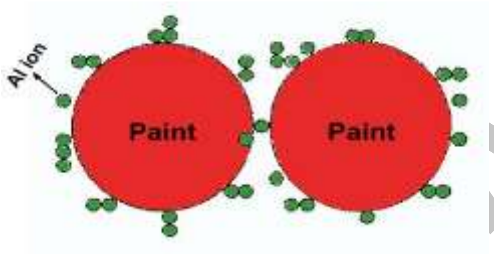

Figure 5: Illustration of surrounding paint ions by *Al* ions

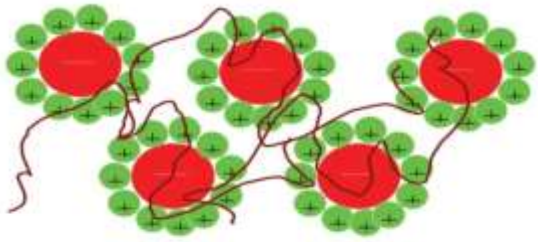

Figure 6. Coagulating-Flocculation phenomena on paint particles (ions)bypresence of the coagulant-flocculant powder in paint contained waste water

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کارگاه آموزشی
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کارگاه آموزشی
آموزش مهارت های کاربردی در تدوین و چاپ مقالات ISI

Appendix B Data for waste RPM and wash water

ENVIROLAB GROUP ENVIROLAB SERVICES mpl

CHAIN OF CUSTODY FORM - Client

ENVIROLAB GROUP
National phone number 1300 424 344

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
☎ 02 9910 6200 | ✉ sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt, Myaree, WA 6154
☎ 08 9317 2505 | ✉ lab@mpl.com.au

Melbourne Lab - Envirolab Services
25 Research Drive, Croydon South, VIC 3136
☎ 03 9763 2500 | ✉ melbourne@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
☎ 08 7087 6800 | ✉ adelaide@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
☎ 07 3266 9532 | ✉ brisbane@envirolab.com.au

Darwin Office - Envirolab Services
Unit 20/119 Reichardt Road, Winnellie, NT 0820
☎ 08 8967 1201 | ✉ darwin@envirolab.com.au

Company: EnRiskS / ARRB / TMR
Contact Person: Ruth Jarman EnRiskS (0447 084 439
Project Mgr: Christine Howland ARRB (0499 850 115)
Sampler: Multiple, via Christine Howland
Address: 21 McLachlan Street, Fortitude Valley QLD
Phone: **Mob:** 0499 850 115
Email Results to: ruth@enrisks.com.au
christine.howland@arrb.com.au
Email Invoice to: christine.howland@arrb.com.au

Client Project Name/Number/Site etc (ie report title): NACOE031
PO No. (if applicable):
Envirolab Quote No. : 22SY408_rev 2 Attached.
Date results required:
Or choose: ☑ Standard ☐ Same Day ☐ 1 day ☐ 2 day ☐ 3 day

Note: Inform lab in advance if urgent turnaround is required - surcharges apply

Additional report format: ☐ Esdat ☐ Equis
Lab Comments:

Sample information					PO No. (if applicable):			Comments
Envirolab Sample ID (Lab use only)	Client Sample ID or Information	Depth	Date Sampled	Type of Sample	On hold pending intial results	Per quote - paint washwater	Per quote - solid RPM tests	Provide as much information about the sample as you can
1	RPM Gold Coast	N/A	8/11/2022	Solid (plastic/bitumen)	X			
2	Rockhampton RPM	N/A	7/11/2022	Solid (plastic/bitumen)	X			
3	RPM Toowoomba	N/A	17/11/2022	Solid (plastic/bitumen)			X	Prep, crushing and analysis of solids only initally, no ASLP as yet
4	DSW 1	N/A	17/11/2022	Washwater		X		
5	DSW 2	N/A	17/11/2022	Washwater	X			
6	DSW 3	N/A	17/11/2022	Washwater	X			

☐ *Please tick the box if observed settled sediment present in water samples is to be included in the extraction and/or analysis*

Relinquished by (Company): ARRB (via courier)	**Received by (Company):** Envirolab Brisbane	24.4 °C	*Lab Use Only*
Print Name: Christine Howland	**Print Name:** Kylie Martin	**Job number:** 311229	**Cooling:** Ice / [✓ Ice pack] / None
Date & Time: 17/11/2022 0:00	**Date & Time:** 21/11/22	**Temperature:** 12°C	**Security seal:** [✓ Intact] / Broken / None
Signature:	**Signature:**	**TAT Req - SAME day / 1 / 2 / 3 / 4 / STD**	

22/11/2022 1000

NATA Accreditation

Envirolab has a large NATA scope of accreditation (Accreditation number 2901).
The RPM samples would not be covered by NATA Accreditation.

Turnaround Times (TAT)

Non-Routine Analysis	10 Working Days

Samples received after 3.00pm are deemed to have been received the following working day and the turnaround time will be adjusted accordingly. TAT begins on receipt of all samples accompanied by a correct COC.

Samples to the lab

You can either send samples direct to our Sydney Lab in Chatswood, or alternatively deliver them to our Brisbane office in Banyo for free shipping to Sydney Lab.

Please note that Envirolab takes no responsibility for delays or breakages by Envirolab-organised commercial couriers.

Prices

Analyte	PQL[1]	No.	Unit Rate $	Total Rate $
RPM-Raised Pavement Markers				
Prep (crushing a 1kg bag of RPM's) #	na	3	120.00	360.00
TRH (C6-C40) + BTEX + Styrene (TRH with silica gel)	25/50/100/100 + 1/1/1/2/1 mg/kg	3	200.00	600.00
PAH's	0.05 – 0.2 mg/kg	3	130.00	390.00
Speciated Phenols	0.2 – 10 mg/kg	3	180.00	540.00
Sb, As, Ba, Be, B, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Ag, V, Zn	0.01 – 5 mg/kg	3	72.00	216.00
Hex Cr	1 mg/kg	3	44.00	132.00
pH	0.1 unit	3	10.00	30.00
Total for the solid RPM (ex GST)				**2,268.00**
ASLP Neutral Leach Tumble	Na	3	45.00	135.00
ASLP Neutral Leach Tumble ZHS (for volatiles)	Na	3	115.00	345.00
PAH's	1 - 2 ug/L	3	65.00	195.00
BTEX + Styrene	1 - 2 ug/L	3	45.00	135.00
Speciated Phenols	1 - 20 ug/L	3	90.00	270.00
Sb, As, Ba, Be, B, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Ag, V, Zn	0.00005 – 0.2 mg/L	3	36.00	108.00
Hex Cr	0.005 mg/L	3	22.00	66.00
pH	0.1 unit	3	5.00	15.00
Total for the ASLP RPM (ex GST)				**1,269.00**
			Admin Fee per job	25.00
			Estimated Total Fee ex GST:	**3,562.00**
			GST	**356.20**
			Estimated Total Fee incl GST:	**3,918.20**

Notes: **1.** PQLs quoted are targets only based on soil and will likely be revised if it becomes apparent that the sample contains substances that cause matrix interference, or where dilutions are required.

\# Prep of RPM – we will assess samples on receipt. We assume we will be able to put the samples through our chipper to break/smash them into pieces, then we will likely mortar/pestle them into smaller manageable pieces for lab testing. By doing this we hope to make a well mixed sample representing all parts. Each sample will be about 10 x individual RPM's totalling about 1kg. We need to crush the whole bag (1kg) to get a representative sample.

Analyte	PQL[1]	No.	Unit Rate $	Total Rate $
Paint Wash Water				
COD	50 mg/L	3	42.00	126.00
TSS	5 mg/L	3	15.00	45.00
pH	0.1 unit	3	7.00	21.00
EC	2 uS/cm	3	7.00	21.00
BOD	5 mg/L	3	45.00	135.00
Ammonia	0.005 mg/L	3	20.00	60.00
Sb, As, Ba, Be, B, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Ag, V, Zn	0.00005 – 0.2 mg/L	3	36.00	108.00
Hex Cr	0.005 mg/L	3	22.00	66.00
Cyanide – Total	0.004 mg/L	3	42.00	126.00
sTRH C10-C40 (with silica gel)	50/100/100 ug/L	3	65.00	195.00
vTRH + Styrene + VOC's + MEK	10 + 1-10ug/L	3	115.00	345.00
Speciated Phenols	1 – 20 ug/L	3	90.00	270.00
Nitrobenzene (part of explosive suite)	1 – 5 ug/L	3	130.00	390.00
PFAS (extended) trace level - Pre	0.0002 – 0.05ug/L	3	240.00	720.00
TOPA Oxidation Step	Na	3	100.00	300.00
PFAS (extended) routine level - Post	0.01 – 0.5ug/L	3	180.00	540.00
Total for the Paint Wash Water (ex GST)				**3,468.00**
			Admin Fee per job	25.00
			Estimated Total Fee ex GST:	**3,493.00**
			GST	**349.30**
			Estimated Total Fee incl GST:	**3,842.30**

Notes: **1.** PQLs quoted are targets only based on relatively clean water and will likely be revised if it becomes apparent that the sample contains substances that cause matrix interference, or where dilutions are required.

Note: I have quoted our routine water level for PFAS. I don't think there is any point trying a lower level, it will be more expensive and it is highly likely we will need to raise the detection limit anyway.

Comments

The budget estimate is based on good faith and our understanding of the scope at this point in time and takes into account the following assumptions and variation fees:

Administration Fee	Applied once per report. This includes additional jobs where analysis is requested after the samples have been booked in for testing.	$25 .00
Minimum Fee	Applied if your analysis totals less that $100 (Inclusive of the Administration Fee, Reloading Fee/s and Courier Fee/s)	$100.00

- All rates are in AUD and do not include GST which will be added at the current rate of 10%;
- Fees for outsourced analysis quoted are current at the time of quotation, but subject to change;
- Fees for equipment supply quoted are current at the time of quotation, but subject to change;
- **This Quotation Number must be written on the COC for these prices to apply;**
- We reserve the right to increase these prices if the agreed schedule decreases;
- Our Standard Terms & Conditions are available here. If you cannot access this link, please come back to us and we can email a copy through directly.

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

SAMPLE RECEIPT ADVICE

Client Details

Client	enRiskS
Attention	Christine Howland, Ruth Jarman

Sample Login Details

Your reference	enRiskS - NACOE031
Envirolab Reference	311229
Date Sample Received	21/11/2022
Date Instructions Received	21/11/2022
Date Results Expected to be Reported	09/12/2022

Sample Condition

Samples received in appropriate condition for analysis	Yes
No. of Samples Provided	3 Solid, 3 Water
Turnaround Time Requested	Standard
Temperature on Receipt (°C)	12
Cooling Method	Ice Pack
Sampling Date Provided	YES

Comments

Nil

Please direct any queries to:

Aileen Hie	Jacinta Hurst
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Invoice will be emailed separately. Results will be reported only if payment has been made. Details of analysis on the following page:

Sample ID	MAH's in soil	vTRH(C6-C10)/BTEXN in Soil	sTPH in Soil (C10-C40)-Silica	PAHs in Soil	Speciated Phenols in Soil	Misc Soil - Inorg	Misc Inorg - Soil	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Copper	Lead	Mercury	Molybdenum	Nickel	Selenium	Silver	Vanadium	Zinc	VOCs in water	vTRH(C6-C10)/BTEXN in Water	sTPH in Water (C10-C40) NEPM Silica gel	PAHsin Water	Speciated Phenols in water	PFAS in Waters Trace Extended	PFAS in Waters POST-TOPA	Explosives in Water	All metals in water - total	pH	Electrical Conductivity	Total Suspended Solids	Ammonia as N in water	BOD
RPM Gold Coast																																					
Rockhampton RPM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓														
RPM Toowoomba																																					
DSW1																								✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DSW2																																					
DSW3																																					

Sample ID	COD	Hexavalent Chromium, Cr6+	Total Cyanide	On Hold
RPM Gold Coast				✓
Rockhampton RPM				
RPM Toowoomba				✓
DSW1	✓	✓	✓	
DSW2				✓
DSW3				✓

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info

Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt. Requests for longer term sample storage must be received in writing.
Please contact the laboratory immediately if observed settled sediment present in water samples is to be included in the extraction and/or analysis (exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS analysis where solids are included by default.
TAT for Micro is dependent on incubation. This varies from 3 to 6 days.

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200   fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 311229

Client Details

Client	enRiskS
Attention	Christine Howland, Ruth Jarman
Address	PO Box 2537, Carlingford Court, NSW, 2118

Sample Details

Your Reference	**enRiskS - NACOE031**
Number of Samples	3 Solid, 3 Water
Date samples received	21/11/2022
Date completed instructions received	21/11/2022

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	09/12/2022
Date of Issue	09/12/2022

This document shall not be reproduced except in full.

Results Approved By

Alexander Mitchell Maclean, Senior Chemist
Diego Bigolin, Inorganics Supervisor
Giovanni Agosti, Group Technical Manager
Josh Williams, Organics and LC Supervisor
Kyle Gavrily, Senior Chemist
Liam Timmins, Organic Instruments Team Leader
Loren Bardwell, Development Chemist
Phalak Inthakesone, Organics Development Manager, Sydney

Authorised By

Nancy Zhang, Laboratory Manager

MAH's in soil		
Our Reference		311229-2
Your Reference	UNITS	Rockhampton RPM
Date Sampled		7/11/2022
Type of sample		Solid
Date extracted	-	25/11/2022
Date analysed	-	28/11/2022
Benzene	mg/kg	<0.2
Toluene	mg/kg	3
Ethylbenzene	mg/kg	4
m+p-xylene	mg/kg	<2
o-Xylene	mg/kg	<1
styrene	mg/kg	22
isopropylbenzene	mg/kg	<1
n-propyl benzene	mg/kg	<1
1,3,5-trimethyl benzene	mg/kg	<1
tert-butyl benzene	mg/kg	<1
1,2,4-trimethyl benzene	mg/kg	<1
sec-butyl benzene	mg/kg	<1
4-isopropyl toluene	mg/kg	<1
n-butyl benzene	mg/kg	<1
Surrogate Dibromofluorometha	%	96
Surrogate aaa-Trifluorotoluene	%	83
Surrogate Toluene-d_8	%	100
Surrogate 4-Bromofluorobenzene	%	101

vTRH(C6-C10)/BTEXN in Soil		
Our Reference		311229-2
Your Reference	UNITS	Rockhampton RPM
Date Sampled		7/11/2022
Type of sample		Solid
Date extracted	-	25/11/2022
Date analysed	-	28/11/2022
TRH C_6 - C_9	mg/kg	26
TRH C_6 - C_{10}	mg/kg	67
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	61
Benzene	mg/kg	<0.2
Toluene	mg/kg	3
Ethylbenzene	mg/kg	4
m+p-xylene	mg/kg	<2
o-Xylene	mg/kg	<1
Naphthalene	mg/kg	<1
Total +ve Xylenes	mg/kg	<1
Surrogate aaa-Trifluorotoluene	%	83

svTRH (C10-C40) in Soil		
Our Reference		311229-2
Your Reference	UNITS	Rockhampton RPM
Date Sampled		7/11/2022
Type of sample		Solid
Date extracted	-	25/11/2022
Date analysed	-	25/11/2022
TRH C_{10} - C_{14}	mg/kg	500
TRH C_{15} - C_{28}	mg/kg	5,900
TRH C_{29} - C_{36}	mg/kg	1,400
Total +ve TRH (C10-C36)	mg/kg	7,800
TRH >C_{10} -C_{16}	mg/kg	700
TRH >C_{10} - C_{16} less Naphthalene (F2)	mg/kg	700
TRH >C_{16} -C_{34}	mg/kg	6,600
TRH >C_{34} -C_{40}	mg/kg	1,500
Total +ve TRH (>C10-C40)	mg/kg	8,800
Surrogate o-Terphenyl	%	#

PAHs in Soil		
Our Reference		311229-2
Your Reference	UNITS	Rockhampton RPM
Date Sampled		7/11/2022
Type of sample		Solid
Date extracted	-	01/12/2022
Date analysed	-	06/12/2022
Naphthalene	mg/kg	13
Acenaphthylene	mg/kg	<2.0
Acenaphthene	mg/kg	<2.0
Fluorene	mg/kg	<2.0
Phenanthrene	mg/kg	<2.0
Anthracene	mg/kg	<2.0
Fluoranthene	mg/kg	<2.0
Pyrene	mg/kg	<2.0
Benzo(a)anthracene	mg/kg	<2.0
Chrysene	mg/kg	<2.0
Benzo(b,j+k)fluoranthene	mg/kg	<4.0
Benzo(a)pyrene	mg/kg	<1.0
Indeno(1,2,3-c,d)pyrene	mg/kg	<2.0
Dibenzo(a,h)anthracene	mg/kg	<2.0
Benzo(g,h,i)perylene	mg/kg	<2.0
Total +ve PAH's	mg/kg	13
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<10
Benzo(a)pyrene TEQ calc(half)	mg/kg	<10
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<10
Surrogate p-Terphenyl-d14	%	101

Speciated Phenols in Soil		
Our Reference		311229-2
Your Reference	UNITS	Rockhampton RPM
Date Sampled		7/11/2022
Type of sample		Solid
Date extracted	-	01/12/2022
Date analysed	-	06/12/2022
Phenol	mg/kg	29
2-Chlorophenol	mg/kg	<4.0
4-Chloro-3-methylphenol	mg/kg	<20
2-Methylphenol (o-cresol)	mg/kg	<4.0
3/4-Methylphenol (m/p-cresol)	mg/kg	<8.0
2-Nitrophenol	mg/kg	<4.0
2,4 -Dimethylphenol	mg/kg	<4.0
2,4-Dichlorophenol	mg/kg	<4.0
2,6-Dichlorophenol	mg/kg	<4.0
2,4,5-Trichlorophenol	mg/kg	<4.0
2,4,6-Trichlorophenol	mg/kg	<4.0
2,4-Dinitrophenol	mg/kg	<80
4-Nitrophenol	mg/kg	<80
2346-Tetrachlorophenol	mg/kg	<4.0
2-methyl-4,6-Dinitrophenol	mg/kg	<40
Pentachlorophenol	mg/kg	<20
Surrogate 2-fluorophenol	%	90
Surrogate Phenol-d_6	%	84
Surrogate 2,4,6-Tribromophenol	%	66
Surrogate *p*-Terphenyl-d_{14}	%	101

Misc Soil - Inorg		
Our Reference		311229-2
Your Reference	UNITS	Rockhampton RPM
Date Sampled		7/11/2022
Type of sample		Solid
Date prepared	-	28/11/2022
Date analysed	-	28/11/2022
Hexavalent Chromium, Cr^{6+}	mg/kg	<1

Misc Inorg - Soil		
Our Reference		311229-2
Your Reference	UNITS	Rockhampton RPM
Date Sampled		7/11/2022
Type of sample		Solid
Date prepared	-	29/11/2022
Date analysed	-	29/11/2022
pH 1:5 soil:water	pH Units	9.4

Acid Extractractable metals in soil		
Our Reference		311229-2
Your Reference	UNITS	Rockhampton RPM
Date Sampled		7/11/2022
Type of sample		Solid
Date prepared	-	08/12/2022
Date analysed	-	08/12/2022
Antimony	mg/kg	<7
Arsenic	mg/kg	<4
Barium	mg/kg	<1
Beryllium	mg/kg	<1
Boron	mg/kg	<3
Cadmium	mg/kg	<0.4
Chromium	mg/kg	<1
Copper	mg/kg	2
Lead	mg/kg	<1
Mercury	mg/kg	<0.1
Molybdenum	mg/kg	<1
Nickel	mg/kg	<1
Selenium	mg/kg	<2
Silver	mg/kg	<1
Vanadium	mg/kg	2
Zinc	mg/kg	<1

VOCs in water		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date extracted	-	28/11/2022
Date analysed	-	29/11/2022
MEK	µg/L	<1000
Dichlorodifluoromethane	µg/L	<1000
Chloromethane	µg/L	<1000
Vinyl Chloride	µg/L	<1000
Bromomethane	µg/L	<1000
Chloroethane	µg/L	<1000
Trichlorofluoromethane	µg/L	<1000
1,1-Dichloroethene	µg/L	<100
Trans-1,2-dichloroethene	µg/L	<100
1,1-dichloroethane	µg/L	<100
Cis-1,2-dichloroethene	µg/L	<100
Bromochloromethane	µg/L	<100
Chloroform	µg/L	<100
2,2-dichloropropane	µg/L	<100
1,2-dichloroethane	µg/L	<100
1,1,1-trichloroethane	µg/L	<100
1,1-dichloropropene	µg/L	<100
Cyclohexane	µg/L	<100
Carbon tetrachloride	µg/L	<100
Benzene	µg/L	<100
Dibromomethane	µg/L	<100
1,2-dichloropropane	µg/L	<100
Trichloroethene	µg/L	<100
Bromodichloromethane	µg/L	<100
trans-1,3-dichloropropene	µg/L	<100
cis-1,3-dichloropropene	µg/L	<100
1,1,2-trichloroethane	µg/L	<100
Toluene	µg/L	<100
1,3-dichloropropane	µg/L	<100
Dibromochloromethane	µg/L	<100
1,2-dibromoethane	µg/L	<100
Tetrachloroethene	µg/L	<100
1,1,1,2-tetrachloroethane	µg/L	<100
Chlorobenzene	µg/L	<100

VOCs in water		
Our Reference	UNITS	311229-4
Your Reference		DSW1
Date Sampled		17/11/2022
Type of sample		Water
Ethylbenzene	µg/L	<100
Bromoform	µg/L	<100
m+p-xylene	µg/L	<200
Styrene	µg/L	<100
1,1,2,2-tetrachloroethane	µg/L	<100
o-xylene	µg/L	<100
1,2,3-trichloropropane	µg/L	<100
Isopropylbenzene	µg/L	<100
Bromobenzene	µg/L	<100
n-propyl benzene	µg/L	<100
2-chlorotoluene	µg/L	<100
4-chlorotoluene	µg/L	<100
1,3,5-trimethyl benzene	µg/L	<100
Tert-butyl benzene	µg/L	<100
1,2,4-trimethyl benzene	µg/L	<100
1,3-dichlorobenzene	µg/L	<100
Sec-butyl benzene	µg/L	<100
1,4-dichlorobenzene	µg/L	<100
4-isopropyl toluene	µg/L	<100
1,2-dichlorobenzene	µg/L	<100
n-butyl benzene	µg/L	<100
1,2-dibromo-3-chloropropane	µg/L	<100
1,2,4-trichlorobenzene	µg/L	<100
Hexachlorobutadiene	µg/L	<100
1,2,3-trichlorobenzene	µg/L	<100
Surrogate Dibromofluoromethane	%	104
Surrogate toluene-d8	%	99
Surrogate 4-BFB	%	103

vTRH(C6-C10)/BTEXN in Water		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date extracted	-	28/11/2022
Date analysed	-	28/11/2022
TRH C_6 - C_9	μg/L	<1000
TRH C_6 - C_{10}	μg/L	<1000
TRH C_6 - C_{10} less BTEX (F1)	μg/L	<10
Benzene	μg/L	<100
Toluene	μg/L	<100
Ethylbenzene	μg/L	<100
m+p-xylene	μg/L	<200
o-xylene	μg/L	<100
Naphthalene	μg/L	<100
Surrogate Dibromofluoromethane	%	104
Surrogate toluene-d8	%	99
Surrogate 4-BFB	%	103

sTPH in Water (C10-C40) NEPM Silica gel		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date extracted	-	23/11/2022
Date analysed	-	25/11/2022
TPH C_{10} - C_{14}	µg/L	<500
TPH C_{15} - C_{28}	µg/L	<1000
TPH C_{29} - C_{36}	µg/L	<1000
TPH >C_{10} - C_{16}	µg/L	<500
TPH >C_{16} - C_{34}	µg/L	<1000
TPH >C_{34} - C_{40}	µg/L	<1000
Surrogate o-Terphenyl	%	112

PAHs in Water		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date extracted	-	23/11/2022
Date analysed	-	24/11/2022
Naphthalene	µg/L	<10
Acenaphthylene	µg/L	<10
Acenaphthene	µg/L	<10
Fluorene	µg/L	<10
Phenanthrene	µg/L	<10
Anthracene	µg/L	<10
Fluoranthene	µg/L	<10
Pyrene	µg/L	<10
Benzo(a)anthracene	µg/L	<10
Chrysene	µg/L	<10
Benzo(b,j+k)fluoranthene	µg/L	<20
Benzo(a)pyrene	µg/L	<10
Indeno(1,2,3-c,d)pyrene	µg/L	<10
Dibenzo(a,h)anthracene	µg/L	<10
Benzo(g,h,i)perylene	µg/L	<10
Benzo(a)pyrene TEQ	µg/L	<5
Total +ve PAH's	µg/L	NIL (+)VE
Surrogate p-Terphenyl-d14	%	#

Speciated Phenols in water		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date extracted	-	23/11/2022
Date analysed	-	24/11/2022
Phenol	µg/L	15
2-Chlorophenol	µg/L	<10
4-Chloro-3-Methylphenol	µg/L	<50
2-Methylphenol (0-Cresol)	µg/L	<10
3/4-Methylphenol (m/p-Cresol)	µg/L	53
2-Nitrophenol	µg/L	<10
2,4-Dimethylphenol	µg/L	<10
2,4-Dichlorophenol	µg/L	<10
2,6-Dichlorophenol	µg/L	<10
2,4,5-Trichlorophenol	µg/L	<10
2,4,6-Trichlorophenol	µg/L	<10
2,4-Dinitrophenol	µg/L	<200
4-Nitrophenol	µg/L	<200
2346-Tetrachlorophenol	µg/L	<10
2-methyl-4,6-Dinitrophenol	µg/L	<100
Pentachlorophenol	µg/L	<50
Surrogate 2-fluorophenol	%	#
Surrogate Phenol-d_6	%	#
Surrogate 2,4,6-Tribromophenol	%	#
Surrogate *p*-Terphenyl-d_{14}	%	#

PFAS in Waters Trace Extended		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date prepared	-	28/11/2022
Date analysed	-	28/11/2022
Perfluorobutanesulfonic acid	µg/L	<0.1
Perfluoropentanesulfonic acid	µg/L	<0.1
Perfluorohexanesulfonic acid - PFHxS	µg/L	<0.1
Perfluoroheptanesulfonic acid	µg/L	<0.1
Perfluorooctanesulfonic acid PFOS	µg/L	<0.1
Perfluorodecanesulfonic acid	µg/L	<0.2
Perfluorobutanoic acid	µg/L	<0.4
Perfluoropentanoic acid	µg/L	0.83
Perfluorohexanoic acid	µg/L	0.88
Perfluoroheptanoic acid	µg/L	0.14
Perfluorooctanoic acid PFOA	µg/L	<0.1
Perfluorononanoic acid	µg/L	<0.1
Perfluorodecanoic acid	µg/L	<0.4
Perfluoroundecanoic acid	µg/L	<0.2
Perfluorododecanoic acid	µg/L	<0.5
Perfluorotridecanoic acid	µg/L	<1
Perfluorotetradecanoic acid	µg/L	<5
4:2 FTS	µg/L	<0.1
6:2 FTS	µg/L	<0.1
8:2 FTS	µg/L	<0.2
10:2 FTS	µg/L	<0.2
Perfluorooctane sulfonamide	µg/L	<1
N-Methyl perfluorooctane sulfonamide	µg/L	<1
N-Ethyl perfluorooctanesulfon amide	µg/L	<1
N-Me perfluorooctanesulfonamid oethanol	µg/L	<0.5
N-Et perfluorooctanesulfonamid oethanol	µg/L	<5
MePerfluorooctanesulf- amid oacetic acid	µg/L	<0.4
EtPerfluorooctanesulf- amid oacetic acid	µg/L	<0.2
Surrogate $^{13}C_8$ *PFOS*	%	108
Surrogate $^{13}C_2$ *PFOA*	%	99
Extracted ISTD $^{13}C_3$ *PFBS*	%	93
Extracted ISTD $^{18}O_2$ *PFHxS*	%	131
Extracted ISTD $^{13}C_4$ *PFOS*	%	103
Extracted ISTD $^{13}C_4$ *PFBA*	%	47

PFAS in Waters Trace Extended		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Extracted ISTD $^{13}C_3$ *PFPeA*	%	82
Extracted ISTD $^{13}C_2$ *PFHxA*	%	91
Extracted ISTD $^{13}C_4$ *PFHpA*	%	86
Extracted ISTD $^{13}C_4$ *PFOA*	%	83
Extracted ISTD $^{13}C_5$ *PFNA*	%	103
Extracted ISTD $^{13}C_2$ *PFDA*	%	36
Extracted ISTD $^{13}C_2$ *PFUnDA*	%	73
Extracted ISTD $^{13}C_2$ *PFDoDA*	%	113
Extracted ISTD $^{13}C_2$ *PFTeDA*	%	51
Extracted ISTD $^{13}C_2$ *4:2FTS*	%	#
Extracted ISTD$^{13}C_2$ *6:2FTS*	%	#
Extracted ISTD $^{13}C_2$ *8:2FTS*	%	#
Extracted ISTD $^{13}C_8$ *FOSA*	%	87
Extracted ISTD d_3 *N MeFOSA*	%	40
Extracted ISTD d_5 *N EtFOSA*	%	130
Extracted ISTD d_7 *N MeFOSE*	%	130
Extracted ISTD d_9 *N EtFOSE*	%	82
Extracted ISTD d_3 *N MeFOSAA*	%	47
Extracted ISTD d_5 *N EtFOSAA*	%	102
Total Positive PFHxS & PFOS	µg/L	<0.1
Total Positive PFOS & PFOA	µg/L	<0.1
Total Positive PFAS	µg/L	1.9

PFAS in Waters POST-TOPA		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date prepared	-	02/12/2022
Date analysed	-	06/12/2022
Perfluorobutanesulfonic acid	µg/L	<0.1
Perfluoropentanesulfonic acid	µg/L	<0.1
Perfluorohexanesulfonic acid - PFHxS	µg/L	<0.1
Perfluoroheptanesulfonic acid	µg/L	<0.1
Perfluorooctanesulfonic acid - PFOS	µg/L	<0.1
Perfluorodecanesulfonic acid	µg/L	<0.2
Perfluorobutanoic acid	µg/L	0.28
Perfluoropentanoic acid	µg/L	0.77
Perfluorohexanoic acid	µg/L	0.66
Perfluoroheptanoic acid	µg/L	0.11
Perfluorooctanoic acid - PFOA	µg/L	<0.1
Perfluorononanoic acid	µg/L	<0.1
Perfluorodecanoic acid	µg/L	<0.2
Perfluoroundecanoic acid	µg/L	<0.2
Perfluorododecanoic acid	µg/L	<0.5
Perfluorotridecanoic acid	µg/L	<1
Perfluorotetradecanoic acid	µg/L	<5.0
4:2 FTS	µg/L	<0.1
6:2 FTS	µg/L	<0.1
8:2 FTS	µg/L	<0.2
10:2 FTS	µg/L	<0.2
Perfluorooctane sulfonamide	µg/L	<1
N-Methyl perfluorooctane sulfonamide	µg/L	<0.5
N-Ethyl perfluorooctanesulfon amide	µg/L	<1
N-Me perfluorooctanesulfonamid oethanol	µg/L	<0.5
N-Et perfluorooctanesulfonamid oethanol	µg/L	<5
MePerfluorooctanesulfamid oacetic acid	µg/L	<0.2
EtPerfluorooctanesulfamid oacetic acid	µg/L	<0.2
Surrogate $^{13}C_2$ PFOA	%	97
Oxidation Efficiency $^{13}C_8$ *FOSA*	%	99

Explosives in Water		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date Extracted	-	09/12/2022
Date analysed	-	09/12/2022
HMX	µg/L	<100
RDX	µg/L	<100
1,3,5-Trinitrobenzene	µg/L	<100
1,3-Dinitrobenzene	µg/L	<100
Tetryl	µg/L	<100
2,4,6-Trinitrotoluene	µg/L	<100
4-&2-AM-DNT(Isomeric Mixture)	µg/L	<200
2,4-Dinitrotoluene	µg/L	<100
2,6-Dinitrotoluene	µg/L	<100
Nitrobenzene	µg/L	<100
2-Nitrotoluene & 4-Nitrotoluene	µg/L	<500
3-Nitrotoluene	µg/L	<100
Nitroglycerine	µg/L	<100
PETN	µg/L	<100
3,5-Dinitroaniline	µg/L	<100
Surrogate (Dinitrobenzene)	%	88

All metals in water - total		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date prepared	-	24/11/2022
Date analysed	-	24/11/2022
Antimony-Total	µg/L	<1
Arsenic-Total	µg/L	7
Barium-Total	µg/L	300
Beryllium-Total	µg/L	<0.5
Boron-Total	µg/L	90
Silver-Total	µg/L	<1
Cadmium-Total	µg/L	0.2
Chromium-Total	µg/L	1
Copper-Total	µg/L	49
Mercury-Total	µg/L	<0.05
Molybdenum-Total	µg/L	<1
Nickel-Total	µg/L	55
Lead-Total	µg/L	4
Selenium-Total	µg/L	<1
Vanadium-Total	µg/L	<1
Zinc-Total	µg/L	280

Miscellaneous Inorganics		
Our Reference		311229-4
Your Reference	UNITS	DSW1
Date Sampled		17/11/2022
Type of sample		Water
Date prepared	-	22/11/2022
Date analysed	-	22/11/2022
pH	pH Units	7.3
Electrical Conductivity	µS/cm	2,100
Total Suspended Solids	mg/L	660
Ammonia as N in water	mg/L	4.4
BOD	mg/L	5,170
COD	mg O_2 /L	7,800
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005
Total Cyanide	mg/L	<0.004

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjusted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hypochlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-019	Suspended Solids - determined gravimetricially by filtration of the sample. The samples are dried at 104+/-5°C.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Inorg-067	Samples are digested in acid with a known excess of potassium dichromate then titrated against ammonium ferrous sulphate in accordance with APHA latest edition 5220 C.
Inorg-091	BOD - Analysed in accordance with APHA latest edition 5210 D and in house INORG-091.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis. Note, the Total +ve TRH PQL is reflective of the lowest individual PQL and is therefore "Total +ve TRH" is simply a sum of the positive individual TRH fractions (>C10-C40).
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS.

Method ID	Methodology Summary
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS and/or GC-MS/MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'EQ PQL'values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'EQ zero'values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'EQ half PQL'values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore "Total +ve PAHs" is simply a sum of the positive individual PAHs.
Org-023	Water samples are analysed directly by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater. Note, the Total +ve Xylene PQL is reflective of the lowest individual PQL and is therefore "Total +ve Xylenes" is simply a sum of the positive individual Xylenes.
Org-029	Soil samples are extracted with acetonitrile. Waters and soil extracts are directly injected and/or concentrated/extracted using SPE. Analysis is undertaken with LC-MSMS.

Method ID	Methodology Summary
Org-029	Soil samples are extracted with basified Methanol. Waters and soil extracts are directly injected and/or concentrated/extracted using SPE. TCLPs/ASLP leachates are centrifuged, the supernatant is then analysed (including amendment with solvent) - as per the option in AS4439.3. Analysis is undertaken with LC-MS/MS. PFAS results include the sum of branched and linear isomers where applicable. Please note that PFAS results are corrected for Extracted Internal Standards (QSM 5.4 Table B-15 terminology), which are mass labelled analytes added prior to sample preparation to assess matrix effects and verify processing of the sample. PFAS analytes without a commercially available mass labelled analogue are corrected vs a closely eluting mass labelled PFAS compound. Surrogates are also reported, in this context they are mass labelled PFAS compounds added prior to extraction but are used as monitoring compounds only (not used for result correction). Envicarb (or similar) is used discretionally to remove interfering matrix components. Please contact the laboratory if estimates of Measurement Uncertainty are required as per WA DER.
Org-029	Foam samples for PFAS are diluted initially by mass and then further diluted as required prior to analysis. Soil samples are extracted with basified Methanol. Waters and soil extracts are directly injected and/or concentrated using SPE. Analysis is undertaken with LC-MS/MS. PFAS results include the sum of branched and linear isomers where applicable. Please note that PFAS results are corrected for Extracted Internal Standards (QSM 5.4 Table B-15 terminology), which are mass labelled analytes added prior to sample preparation to assess matrix effects and verify processing of the sample. PFAS analytes without a commercially available mass labelled analogue are corrected vs a closely eluting mass labelled PFAS compound. Surrogates are also reported, in this context they are mass labelled PFAS compounds added prior to extraction but are used as monitoring compounds only (not used for result correction). Envicarb (or similar) is used discretionally to remove interfering matrix components. TOPA analyses use a pre-spiked, labelled internal standard PFAS precursor to assess the oxidation efficiency. The efficiency of removal by oxidation is recorded in the report. Additionally, dilutions applied (if required) to ensure sufficient precursor oxidation are also recorded and are available on request. Total Oxidisable Precursor Assay (TOPA) where aqueous and sediment/sludge/soil extracts are treated with alkali persulphate. Analysis is carried out before and after the treatment in order to indicate if there are precursors present that may ‘iotransform’into more persistent daughter products (e.g. PFAAs and PFSAs). TOPA is a semi-quantitative test as it may only give an indication of the presence of PFAS that are not detected/measurable without the oxidative step. For solid extracts, only the extractable pre-cursors in basified Methanol may be oxidised to PFAAs. The test will rarely provide a fluoride mass balance. The results must be used in conjunction with an understanding of the limitations and typical performance criteria required. Please contact the laboratory if estimates of Measurement Uncertainty are required as per WA DER.

Method ID	Methodology Summary
Org-029A	Soil samples are extracted with basified Methanol. Waters and soil extracts are directly injected and/or concentrated/extracted using SPE. TCLPs/ASLP leachates are centrifuged, the supernatant is then analysed (including amendment with solvent) - as per the option in AS4439.3. Analysis is undertaken with LC-MS/MS PFAS results include the sum of branched and linear isomers where applicable. Please note that PFAS results are corrected for Extracted Internal Standards (QSM 5.4Table B-15 terminology), which are mass labelled analytes added prior to sample preparation to assess matrix effects and verify processing of the sample. PFAS analytes without a commercially available mass labelled analogue are corrected vs a closely eluting mass labelled PFAS compound. Surrogates are also reported, in this context they are mass labelled PFAS compounds added prior to extraction but are used as monitoring compounds only (not used for result correction). Envicarb (or similar) is used discretionally to remove interfering matrix components. TOPA analyses use a pre-spiked, labelled internal standard PFAS precursor to assess the oxidation efficiency. The efficiency of removal by oxidation is recorded in the report. Additionally, dilutions applied (if required) to ensure sufficient precursor oxidation are also recorded and are available on request. Please contact the laboratory if estimates of Measurement Uncertainty are required as per WA DER.

QUALITY CONTROL: MAH's in soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-10	[NT]
Date extracted	-			25/11/2022	[NT]	[NT]	[NT]	[NT]	25/11/2022	[NT]
Date analysed	-			28/11/2022	[NT]	[NT]	[NT]	[NT]	28/11/2022	[NT]
Benzene	mg/kg	0.2	Org-023	<0.2	[NT]	[NT]	[NT]	[NT]	101	[NT]
Toluene	mg/kg	0.5	Org-023	<0.5	[NT]	[NT]	[NT]	[NT]	98	[NT]
Ethylbenzene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	91	[NT]
m+p-xylene	mg/kg	2	Org-023	<2	[NT]	[NT]	[NT]	[NT]	98	[NT]
o-Xylene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
styrene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
isopropylbenzene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
n-propyl benzene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,3,5-trimethyl benzene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
tert-butyl benzene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,2,4-trimethyl benzene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
sec-butyl benzene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
4-isopropyl toluene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
n-butyl benzene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate Dibromofluorometha	%		Org-023	97	[NT]	[NT]	[NT]	[NT]	98	[NT]
Surrogate aaa-Trifluorotoluene	%		Org-023	91	[NT]	[NT]	[NT]	[NT]	98	[NT]
Surrogate Toluene-d_8	%		Org-023	98	[NT]	[NT]	[NT]	[NT]	101	[NT]
Surrogate 4-Bromofluorobenzene	%		Org-023	99	[NT]	[NT]	[NT]	[NT]	100	[NT]

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-10	[NT]
Date extracted	-			25/11/2022	[NT]	[NT]	[NT]	[NT]	25/11/2022	[NT]
Date analysed	-			28/11/2022	[NT]	[NT]	[NT]	[NT]	28/11/2022	[NT]
TRH C_6 - C_9	mg/kg	25	Org-023	<25	[NT]	[NT]	[NT]	[NT]	97	[NT]
TRH C_6 - C_{10}	mg/kg	25	Org-023	<25	[NT]	[NT]	[NT]	[NT]	97	[NT]
Benzene	mg/kg	0.2	Org-023	<0.2	[NT]	[NT]	[NT]	[NT]	101	[NT]
Toluene	mg/kg	0.5	Org-023	<0.5	[NT]	[NT]	[NT]	[NT]	98	[NT]
Ethylbenzene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	91	[NT]
m+p-xylene	mg/kg	2	Org-023	<2	[NT]	[NT]	[NT]	[NT]	98	[NT]
o-Xylene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Naphthalene	mg/kg	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate aaa-Trifluorotoluene	%		Org-023	91	[NT]	[NT]	[NT]	[NT]	98	[NT]

QUALITY CONTROL: svTRH (C10-C40) in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-10	
Date extracted	-			25/11/2022	[NT]	[NT]	[NT]	[NT]	25/11/2022	[NT]
Date analysed	-			25/11/2022	[NT]	[NT]	[NT]	[NT]	25/11/2022	[NT]
TRH C_{10} - C_{14}	mg/kg	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	97	[NT]
TRH C_{15} - C_{28}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	88	[NT]
TRH C_{29} - C_{36}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	100	[NT]
TRH $>C_{10}$ -C_{16}	mg/kg	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	97	[NT]
TRH $>C_{16}$ -C_{34}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	88	[NT]
TRH $>C_{34}$ -C_{40}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	100	[NT]
Surrogate o-Terphenyl	%		Org-020	77	[NT]	[NT]	[NT]	[NT]	77	[NT]

QUALITY CONTROL: PAHs in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-10	[NT]
Date extracted	-			01/12/2022	[NT]	[NT]	[NT]	[NT]	01/12/2022	[NT]
Date analysed	-			06/12/2022	[NT]	[NT]	[NT]	[NT]	06/12/2022	[NT]
Naphthalene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Acenaphthylene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	108	[NT]
Fluorene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	116	[NT]
Phenanthrene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	120	[NT]
Anthracene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	119	[NT]
Pyrene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	126	[NT]
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	69	[NT]
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	<0.05	[NT]	[NT]	[NT]	[NT]	106	[NT]
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	87	[NT]	[NT]	[NT]	[NT]	88	[NT]

QUALITY CONTROL: Speciated Phenols in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-10	[NT]
Date extracted	-			01/12/2022	[NT]	[NT]	[NT]	[NT]	01/12/2022	[NT]
Date analysed	-			06/12/2022	[NT]	[NT]	[NT]	[NT]	06/12/2022	[NT]
Phenol	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	95	[NT]
2-Chlorophenol	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	99	[NT]
4-Chloro-3-methylphenol	mg/kg	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-Methylphenol (o-cresol)	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	98	[NT]
3/4-Methylphenol (m/p-cresol)	mg/kg	0.4	Org-022/025	<0.4	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-Nitrophenol	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4 -Dimethylphenol	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4-Dichlorophenol	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,6-Dichlorophenol	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	137	[NT]
2,4,5-Trichlorophenol	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4,6-Trichlorophenol	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4-Dinitrophenol	mg/kg	4	Org-022/025	<4	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
4-Nitrophenol	mg/kg	4	Org-022/025	<4	[NT]	[NT]	[NT]	[NT]	91	[NT]
2346-Tetrachlorophenol	mg/kg	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-methyl-4,6-Dinitrophenol	mg/kg	2	Org-022/025	<2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Pentachlorophenol	mg/kg	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	119	[NT]
Surrogate 2-fluorophenol	%		Org-022/025	89	[NT]	[NT]	[NT]	[NT]	88	[NT]
Surrogate Phenol-d_6	%		Org-022/025	88	[NT]	[NT]	[NT]	[NT]	87	[NT]
Surrogate 2,4,6-Tribromophenol	%		Org-022/025	89	[NT]	[NT]	[NT]	[NT]	87	[NT]
Surrogate p-Terphenyl-d_{14}	%		Org-022/025	87	[NT]	[NT]	[NT]	[NT]	88	[NT]

QUALITY CONTROL: Misc Soil - Inorg					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			28/11/2022	[NT]	[NT]	[NT]	[NT]	28/11/2022	[NT]
Date analysed	-			28/11/2022	[NT]	[NT]	[NT]	[NT]	28/11/2022	[NT]
Hexavalent Chromium, Cr^{6+}	mg/kg	1	Inorg-024	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			29/11/2022	[NT]	[NT]	[NT]	[NT]	29/11/2022	[NT]
Date analysed	-			29/11/2022	[NT]	[NT]	[NT]	[NT]	29/11/2022	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	99	[NT]

QUALITY CONTROL: Acid Extractractable metals in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			08/12/2022	[NT]	[NT]	[NT]	[NT]	08/12/2022	[NT]
Date analysed	-			08/12/2022	[NT]	[NT]	[NT]	[NT]	08/12/2022	[NT]
Antimony	mg/kg	7	Metals-020	<7	[NT]	[NT]	[NT]	[NT]	95	[NT]
Arsenic	mg/kg	4	Metals-020	<4	[NT]	[NT]	[NT]	[NT]	96	[NT]
Barium	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Beryllium	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
Boron	mg/kg	3	Metals-020	<3	[NT]	[NT]	[NT]	[NT]	119	[NT]
Cadmium	mg/kg	0.4	Metals-020	<0.4	[NT]	[NT]	[NT]	[NT]	105	[NT]
Chromium	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
Copper	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	107	[NT]
Lead	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Mercury	mg/kg	0.1	Metals-021	<0.1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Molybdenum	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	103	[NT]
Nickel	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Selenium	mg/kg	2	Metals-020	<2	[NT]	[NT]	[NT]	[NT]	94	[NT]
Silver	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	80	[NT]
Vanadium	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	100	[NT]
Zinc	mg/kg	1	Metals-020	<1	[NT]	[NT]	[NT]	[NT]	100	[NT]

QUALITY CONTROL: VOCs in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			28/11/2022	[NT]	[NT]	[NT]	[NT]	28/11/2022	[NT]
Date analysed	-			29/11/2022	[NT]	[NT]	[NT]	[NT]	29/11/2022	[NT]
MEK	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dichlorodifluoromethane	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chloromethane	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Vinyl Chloride	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Bromomethane	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chloroethane	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Trichlorofluoromethane	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,1-Dichloroethene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Trans-1,2-dichloroethene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,1-dichloroethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
Cis-1,2-dichloroethene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Bromochloromethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chloroform	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
2,2-dichloropropane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,2-dichloroethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
1,1,1-trichloroethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	97	[NT]
1,1-dichloropropene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Cyclohexane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Carbon tetrachloride	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibromomethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,2-dichloropropane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Trichloroethene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	116	[NT]
Bromodichloromethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	96	[NT]
trans-1,3-dichloropropene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
cis-1,3-dichloropropene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,1,2-trichloroethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Toluene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,3-dichloropropane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibromochloromethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	97	[NT]
1,2-dibromoethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Tetrachloroethene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	100	[NT]
1,1,1,2-tetrachloroethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chlorobenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Ethylbenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Bromoform	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
m+p-xylene	µg/L	2	Org-023	<2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Styrene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]

QUALITY CONTROL: VOCs in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
1,1,2,2-tetrachloroethane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
o-xylene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,2,3-trichloropropane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Isopropylbenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Bromobenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
n-propyl benzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-chlorotoluene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
4-chlorotoluene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,3,5-trimethyl benzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Tert-butyl benzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,2,4-trimethyl benzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,3-dichlorobenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Sec-butyl benzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,4-dichlorobenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
4-isopropyl toluene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,2-dichlorobenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
n-butyl benzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,2-dibromo-3-chloropropane	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,2,4-trichlorobenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Hexachlorobutadiene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
1,2,3-trichlorobenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	108	[NT]	[NT]	[NT]	[NT]	85	[NT]
Surrogate toluene-d8	%		Org-023	96	[NT]	[NT]	[NT]	[NT]	85	[NT]
Surrogate 4-BFB	%		Org-023	103	[NT]	[NT]	[NT]	[NT]	90	[NT]

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			28/11/2022	[NT]	[NT]	[NT]	[NT]	28/11/2022	[NT]
Date analysed	-			28/11/2022	[NT]	[NT]	[NT]	[NT]	28/11/2022	[NT]
TRH C_6 - C_9	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	109	[NT]
TRH C_6 - C_{10}	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	109	[NT]
Benzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	98	[NT]
Toluene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Ethylbenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	113	[NT]
m+p-xylene	µg/L	2	Org-023	<2	[NT]	[NT]	[NT]	[NT]	115	[NT]
o-xylene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	115	[NT]
Naphthalene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	108	[NT]	[NT]	[NT]	[NT]	85	[NT]
Surrogate toluene-d8	%		Org-023	96	[NT]	[NT]	[NT]	[NT]	85	[NT]
Surrogate 4-BFB	%		Org-023	103	[NT]	[NT]	[NT]	[NT]	90	[NT]

QUALITY CONTROL: sTPH in Water (C10-C40) NEPM Silica gel					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			23/11/2022	[NT]	[NT]	[NT]	[NT]	23/11/2022	[NT]
Date analysed	-			25/11/2022	[NT]	[NT]	[NT]	[NT]	25/11/2022	[NT]
TPH C_{10} - C_{14}	µg/L	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	72	[NT]
TPH C_{15} - C_{28}	µg/L	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	98	[NT]
TPH C_{29} - C_{36}	µg/L	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	105	[NT]
TPH >C_{10} - C_{16}	µg/L	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	72	[NT]
TPH >C_{16} - C_{34}	µg/L	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	98	[NT]
TPH >C_{34} - C_{40}	µg/L	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	105	[NT]
Surrogate o-Terphenyl	%		Org-020	95	[NT]	[NT]	[NT]	[NT]	101	[NT]

QUALITY CONTROL: PAHs in Water					Duplicate					Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date extracted	-			23/11/2022	[NT]	[NT]	[NT]	[NT]	23/11/2022	[NT]
Date analysed	-			24/11/2022	[NT]	[NT]	[NT]	[NT]	24/11/2022	[NT]
Naphthalene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	78	[NT]
Acenaphthylene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Acenaphthene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	90	[NT]
Fluorene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	95	[NT]
Phenanthrene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	102	[NT]
Anthracene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluoranthene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	102	[NT]
Pyrene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Benzo(a)anthracene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chrysene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	89	[NT]
Benzo(b,j+k)fluoranthene	µg/L	2	Org-022/025	<2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(a)pyrene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	92	[NT]
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	81	[NT]	[NT]	[NT]	[NT]	74	[NT]

QUALITY CONTROL: Speciated Phenols in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date extracted	-			23/11/2022	[NT]	[NT]	[NT]	[NT]	23/11/2022	[NT]
Date analysed	-			24/11/2022	[NT]	[NT]	[NT]	[NT]	24/11/2022	[NT]
Phenol	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	33	[NT]
2-Chlorophenol	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	72	[NT]
4-Chloro-3-Methylphenol	µg/L	5	Org-022/025	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-Methylphenol (0-Cresol)	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	60	[NT]
3/4-Methylphenol (m/p-Cresol)	µg/L	2	Org-022/025	<2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-Nitrophenol	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4-Dimethylphenol	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4-Dichlorophenol	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,6-Dichlorophenol	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	102	[NT]
2,4,5-Trichlorophenol	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4,6-Trichlorophenol	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4-Dinitrophenol	µg/L	20	Org-022/025	<20	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
4-Nitrophenol	µg/L	20	Org-022/025	<20	[NT]	[NT]	[NT]	[NT]	42	[NT]
2346-Tetrachlorophenol	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-methyl-4,6-Dinitrophenol	µg/L	10	Org-022/025	<10	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Pentachlorophenol	µg/L	5	Org-022/025	<5	[NT]	[NT]	[NT]	[NT]	90	[NT]
Surrogate 2-fluorophenol	%		Org-022/025	42	[NT]	[NT]	[NT]	[NT]	40	[NT]
Surrogate Phenol-d$_6$	%		Org-022/025	30	[NT]	[NT]	[NT]	[NT]	56	[NT]
Surrogate 2,4,6-Tribromophenol	%		Org-022/025	55	[NT]	[NT]	[NT]	[NT]	66	[NT]
Surrogate *p*-Terphenyl-d$_{14}$	%		Org-022/025	81	[NT]	[NT]	[NT]	[NT]	74	[NT]

QUALITY CONTROL: PFAS in Waters Trace Extended					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date prepared	-			28/11/2022	[NT]	[NT]	[NT]	[NT]	28/11/2022	[NT]
Date analysed	-			28/11/2022	[NT]	[NT]	[NT]	[NT]	28/11/2022	[NT]
Perfluorobutanesulfonic acid	µg/L	0.0004	Org-029	<0.0004	[NT]	[NT]	[NT]	[NT]	105	[NT]
Perfluoropentanesulfonic acid	µg/L	0.001	Org-029	<0.001	[NT]	[NT]	[NT]	[NT]	102	[NT]
Perfluorohexanesulfonic acid - PFHxS	µg/L	0.0002	Org-029	<0.0002	[NT]	[NT]	[NT]	[NT]	95	[NT]
Perfluoroheptanesulfonic acid	µg/L	0.001	Org-029	<0.001	[NT]	[NT]	[NT]	[NT]	95	[NT]
Perfluorooctanesulfonic acid PFOS	µg/L	0.0002	Org-029	<0.0002	[NT]	[NT]	[NT]	[NT]	96	[NT]
Perfluorodecanesulfonic acid	µg/L	0.002	Org-029	<0.002	[NT]	[NT]	[NT]	[NT]	97	[NT]
Perfluorobutanoic acid	µg/L	0.002	Org-029	<0.002	[NT]	[NT]	[NT]	[NT]	95	[NT]
Perfluoropentanoic acid	µg/L	0.002	Org-029	<0.002	[NT]	[NT]	[NT]	[NT]	101	[NT]
Perfluorohexanoic acid	µg/L	0.0004	Org-029	<0.0004	[NT]	[NT]	[NT]	[NT]	98	[NT]
Perfluoroheptanoic acid	µg/L	0.0004	Org-029	<0.0004	[NT]	[NT]	[NT]	[NT]	103	[NT]
Perfluorooctanoic acid PFOA	µg/L	0.0002	Org-029	<0.0002	[NT]	[NT]	[NT]	[NT]	103	[NT]
Perfluorononanoic acid	µg/L	0.001	Org-029	<0.001	[NT]	[NT]	[NT]	[NT]	113	[NT]
Perfluorodecanoic acid	µg/L	0.002	Org-029	<0.002	[NT]	[NT]	[NT]	[NT]	97	[NT]
Perfluoroundecanoic acid	µg/L	0.002	Org-029	<0.002	[NT]	[NT]	[NT]	[NT]	112	[NT]
Perfluorododecanoic acid	µg/L	0.005	Org-029	<0.005	[NT]	[NT]	[NT]	[NT]	97	[NT]
Perfluorotridecanoic acid	µg/L	0.01	Org-029	<0.01	[NT]	[NT]	[NT]	[NT]	90	[NT]
Perfluorotetradecanoic acid	µg/L	0.05	Org-029	<0.05	[NT]	[NT]	[NT]	[NT]	100	[NT]
4:2 FTS	µg/L	0.001	Org-029	<0.001	[NT]	[NT]	[NT]	[NT]	95	[NT]
6:2 FTS	µg/L	0.0004	Org-029	<0.0004	[NT]	[NT]	[NT]	[NT]	101	[NT]
8:2 FTS	µg/L	0.0004	Org-029	<0.0004	[NT]	[NT]	[NT]	[NT]	102	[NT]
10:2 FTS	µg/L	0.002	Org-029	<0.002	[NT]	[NT]	[NT]	[NT]	110	[NT]
Perfluorooctane sulfonamide	µg/L	0.01	Org-029	<0.01	[NT]	[NT]	[NT]	[NT]	101	[NT]
N-Methyl perfluorooctane sulfonamide	µg/L	0.05	Org-029	<0.05	[NT]	[NT]	[NT]	[NT]	89	[NT]
N-Ethyl perfluorooctanesulfon amide	µg/L	0.1	Org-029	<0.1	[NT]	[NT]	[NT]	[NT]	90	[NT]
N-Me perfluorooctanesulfonamid oethanol	µg/L	0.05	Org-029	<0.05	[NT]	[NT]	[NT]	[NT]	101	[NT]
N-Et perfluorooctanesulfonamid oethanol	µg/L	0.5	Org-029	<0.5	[NT]	[NT]	[NT]	[NT]	89	[NT]
MePerfluorooctanesulf- amid oacetic acid	µg/L	0.002	Org-029	<0.002	[NT]	[NT]	[NT]	[NT]	91	[NT]
EtPerfluorooctanesulf- amid oacetic acid	µg/L	0.002	Org-029	<0.002	[NT]	[NT]	[NT]	[NT]	94	[NT]
Surrogate $^{13}C_8$ *PFOS*	%		Org-029	101	[NT]	[NT]	[NT]	[NT]	101	[NT]
Surrogate $^{13}C_2$ *PFOA*	%		Org-029	101	[NT]	[NT]	[NT]	[NT]	101	[NT]

QUALITY CONTROL: PFAS in Waters Trace Extended					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Extracted ISTD $^{13}C_3$ *PFBS*	%		Org-029	86	[NT]	[NT]	[NT]	[NT]	90	[NT]
Extracted ISTD $^{18}O_2$ *PFHxS*	%		Org-029	98	[NT]	[NT]	[NT]	[NT]	102	[NT]
Extracted ISTD $^{13}C_4$ *PFOS*	%		Org-029	92	[NT]	[NT]	[NT]	[NT]	88	[NT]
Extracted ISTD $^{13}C_4$ *PFBA*	%		Org-029	108	[NT]	[NT]	[NT]	[NT]	112	[NT]
Extracted ISTD $^{13}C_3$ *PFPeA*	%		Org-029	92	[NT]	[NT]	[NT]	[NT]	94	[NT]
Extracted ISTD $^{13}C_2$ *PFHxA*	%		Org-029	103	[NT]	[NT]	[NT]	[NT]	108	[NT]
Extracted ISTD $^{13}C_4$ *PFHpA*	%		Org-029	104	[NT]	[NT]	[NT]	[NT]	108	[NT]
Extracted ISTD $^{13}C_4$ *PFOA*	%		Org-029	100	[NT]	[NT]	[NT]	[NT]	96	[NT]
Extracted ISTD $^{13}C_5$ *PFNA*	%		Org-029	106	[NT]	[NT]	[NT]	[NT]	96	[NT]
Extracted ISTD $^{13}C_2$ *PFDA*	%		Org-029	102	[NT]	[NT]	[NT]	[NT]	91	[NT]
Extracted ISTD $^{13}C_2$ *PFUnDA*	%		Org-029	93	[NT]	[NT]	[NT]	[NT]	84	[NT]
Extracted ISTD $^{13}C_2$ *PFDoDA*	%		Org-029	92	[NT]	[NT]	[NT]	[NT]	97	[NT]
Extracted ISTD $^{13}C_2$ *PFTeDA*	%		Org-029	86	[NT]	[NT]	[NT]	[NT]	95	[NT]
Extracted ISTD $^{13}C_2$ *4:2FTS*	%		Org-029	140	[NT]	[NT]	[NT]	[NT]	141	[NT]
Extracted ISTD$^{13}C_2$ *6:2FTS*	%		Org-029	148	[NT]	[NT]	[NT]	[NT]	131	[NT]
Extracted ISTD $^{13}C_2$ *8:2FTS*	%		Org-029	132	[NT]	[NT]	[NT]	[NT]	114	[NT]
Extracted ISTD $^{13}C_8$ *FOSA*	%		Org-029	65	[NT]	[NT]	[NT]	[NT]	64	[NT]
Extracted ISTD d_3 *N MeFOSA*	%		Org-029	106	[NT]	[NT]	[NT]	[NT]	104	[NT]
Extracted ISTD d_5 *N EtFOSA*	%		Org-029	104	[NT]	[NT]	[NT]	[NT]	106	[NT]
Extracted ISTD d_7 *N MeFOSE*	%		Org-029	106	[NT]	[NT]	[NT]	[NT]	108	[NT]

QUALITY CONTROL: PFAS in Waters Trace Extended					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Extracted ISTD d_9 *N EtFOSE*	%		Org-029	105	[NT]	[NT]	[NT]	[NT]	103	[NT]
Extracted ISTD d_3 *N MeFOSAA*	%		Org-029	96	[NT]	[NT]	[NT]	[NT]	83	[NT]
Extracted ISTD d_5 *N EtFOSAA*	%		Org-029	83	[NT]	[NT]	[NT]	[NT]	79	[NT]

QUALITY CONTROL: PFAS in Waters POST-TOPA					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			02/12/2022	4	02/12/2022	02/12/2022		[NT]	[NT]
Date analysed	-			06/12/2022	4	06/12/2022	06/12/2022		[NT]	[NT]
Perfluorobutanesulfonic acid	µg/L	0.01	Org-029A	<0.01	4	<0.1	<0.1	0	[NT]	[NT]
Perfluoropentanesulfonic acid	µg/L	0.01	Org-029A	<0.01	4	<0.1	<0.1	0	[NT]	[NT]
Perfluorohexanesulfonic acid - PFHxS	µg/L	0.01	Org-029A	<0.01	4	<0.1	<0.1	0	[NT]	[NT]
Perfluoroheptanesulfonic acid	µg/L	0.01	Org-029A	<0.01	4	<0.1	<0.1	0	[NT]	[NT]
Perfluorooctanesulfonic acid - PFOS	µg/L	0.01	Org-029A	<0.01	4	<0.1	<0.1	0	[NT]	[NT]
Perfluorodecanesulfonic acid	µg/L	0.02	Org-029A	<0.02	4	<0.2	<0.2	0	[NT]	[NT]
Perfluorobutanoic acid	µg/L	0.02	Org-029A	<0.02	4	0.28	0.29	4	[NT]	[NT]
Perfluoropentanoic acid	µg/L	0.02	Org-029A	<0.02	4	0.77	0.82	6	[NT]	[NT]
Perfluorohexanoic acid	µg/L	0.01	Org-029A	<0.01	4	0.66	0.67	2	[NT]	[NT]
Perfluoroheptanoic acid	µg/L	0.01	Org-029A	<0.01	4	0.11	0.12	9	[NT]	[NT]
Perfluorooctanoic acid - PFOA	µg/L	0.01	Org-029A	<0.01	4	<0.1	<0.1	0	[NT]	[NT]
Perfluorononanoic acid	µg/L	0.01	Org-029A	<0.01	4	<0.1	<0.1	0	[NT]	[NT]
Perfluorodecanoic acid	µg/L	0.02	Org-029A	<0.02	4	<0.2	<0.2	0	[NT]	[NT]
Perfluoroundecanoic acid	µg/L	0.02	Org-029A	<0.02	4	<0.2	<0.2	0	[NT]	[NT]
Perfluorododecanoic acid	µg/L	0.05	Org-029A	<0.05	4	<0.5	<0.5	0	[NT]	[NT]
Perfluorotridecanoic acid	µg/L	0.1	Org-029A	<0.1	4	<1	<1	0	[NT]	[NT]
Perfluorotetradecanoic acid	µg/L	0.5	Org-029A	<0.5	4	<5.0	<5.0	0	[NT]	[NT]
4:2 FTS	µg/L	0.01	Org-029A	<0.01	4	<0.1	<0.1	0	[NT]	[NT]
6:2 FTS	µg/L	0.01	Org-029A	<0.01	4	<0.1	<0.1	0	[NT]	[NT]
8:2 FTS	µg/L	0.02	Org-029A	<0.02	4	<0.2	<0.2	0	[NT]	[NT]
10:2 FTS	µg/L	0.02	Org-029A	<0.02	4	<0.2	<0.2	0	[NT]	[NT]
Perfluorooctane sulfonamide	µg/L	0.1	Org-029A	<0.1	4	<1	<1	0	[NT]	[NT]
N-Methyl perfluorooctane sulfonamide	µg/L	0.05	Org-029A	<0.05	4	<0.5	<0.5	0	[NT]	[NT]
N-Ethyl perfluorooctanesulfon amide	µg/L	0.1	Org-029A	<0.1	4	<1	<1	0	[NT]	[NT]
N-Me perfluorooctanesulfonamid oethanol	µg/L	0.05	Org-029A	<0.05	4	<0.5	<0.5	0	[NT]	[NT]
N-Et perfluorooctanesulfonamid oethanol	µg/L	0.5	Org-029A	<0.5	4	<5	<5	0	[NT]	[NT]
MePerfluorooctanesulfamid oacetic acid	µg/L	0.02	Org-029A	<0.02	4	<0.2	<0.2	0	[NT]	[NT]
EtPerfluorooctanesulfamid oacetic acid	µg/L	0.02	Org-029A	<0.02	4	<0.2	<0.2	0	[NT]	[NT]
Surrogate $^{13}C_2$ PFOA	%		Org-029	91	4	97	96	1	[NT]	[NT]

QUALITY CONTROL: Explosives in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date Extracted	-			09/12/2022	[NT]	[NT]	[NT]	[NT]	09/12/2022	[NT]
Date analysed	-			09/12/2022	[NT]	[NT]	[NT]	[NT]	09/12/2022	[NT]
HMX	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
RDX	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
1,3,5-Trinitrobenzene	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	93	[NT]
1,3-Dinitrobenzene	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	94	[NT]
Tetryl	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	108	[NT]
2,4,6-Trinitrotoluene	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
4-&2-AM-DNT(Isomeric Mixture)	µg/L	2	Org-029	<2	[NT]	[NT]	[NT]	[NT]	184	[NT]
2,4-Dinitrotoluene	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	97	[NT]
2,6-Dinitrotoluene	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
Nitrobenzene	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	103	[NT]
2-Nitrotoluene & 4-Nitrotoluene	µg/L	5	Org-029	<5	[NT]	[NT]	[NT]	[NT]	199	[NT]
3-Nitrotoluene	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Nitroglycerine	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	108	[NT]
PETN	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	97	[NT]
3,5-Dinitroaniline	µg/L	1	Org-029	<1	[NT]	[NT]	[NT]	[NT]	97	[NT]
Surrogate (Dinitrobenzene)	%		Org-029	96	[NT]	[NT]	[NT]	[NT]	94	[NT]

QUALITY CONTROL: All metals in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date prepared	-			24/11/2022	[NT]	[NT]	[NT]	[NT]	24/11/2022	[NT]
Date analysed	-			24/11/2022	[NT]	[NT]	[NT]	[NT]	24/11/2022	[NT]
Antimony-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	93	[NT]
Arsenic-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	96	[NT]
Barium-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	85	[NT]
Beryllium-Total	µg/L	0.5	Metals-022	<0.5	[NT]	[NT]	[NT]	[NT]	107	[NT]
Boron-Total	µg/L	20	Metals-022	<20	[NT]	[NT]	[NT]	[NT]	83	[NT]
Silver-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	100	[NT]
Cadmium-Total	µg/L	0.1	Metals-022	<0.1	[NT]	[NT]	[NT]	[NT]	93	[NT]
Chromium-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	87	[NT]
Copper-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	94	[NT]
Mercury-Total	µg/L	0.05	Metals-021	<0.05	[NT]	[NT]	[NT]	[NT]	104	[NT]
Molybdenum-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	83	[NT]
Nickel-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	92	[NT]
Lead-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Selenium-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	97	[NT]
Vanadium-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	89	[NT]
Zinc-Total	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	90	[NT]

Client Reference: enRiskS - NACOE031

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date prepared	-			22/11/2022	[NT]	[NT]	[NT]	[NT]	22/11/2022	[NT]
Date analysed	-			22/11/2022	[NT]	[NT]	[NT]	[NT]	22/11/2022	[NT]
pH	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	98	[NT]
Electrical Conductivity	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Total Suspended Solids	mg/L	5	Inorg-019	<5	[NT]	[NT]	[NT]	[NT]	94	[NT]
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	[NT]	[NT]	[NT]	[NT]	107	[NT]
BOD	mg/L	5	Inorg-091	<5	[NT]	[NT]	[NT]	[NT]	91	[NT]
COD	mg O_2 /L	50	Inorg-067	<50	[NT]	[NT]	[NT]	[NT]	95	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	<0.005	[NT]	[NT]	[NT]	[NT]	114	[NT]
Total Cyanide	mg/L	0.004	Inorg-014	<0.004	[NT]	[NT]	[NT]	[NT]	95	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

VOC & BTEXN in Water NEPM - The PQL for 311229-4 has been raised due to the sample matrix thereby requiring a dilution.

PFAS in water: PQLs have been raised due to sample matrix interferences.

PAHs in Water - The PQL has been raised due to interferences from analytes (other than those being tested) in sample/s 311229-1.
Speciated Phenols in water - The PQL has been raised due to interferences from analytes (other than those being tested) in sample/s 311229-1.

TRH Soil C10-C40 NEPM - # Percent recovery for the surrogate/matrix spike is not possible to report as the high concentration of analytes in sample 311229-2 have caused interference.

sTPH in Water (C10-C40)-Silica - The PQL for sample 311229-4 has been raised due to the high concentration of analytes in the sample/s, resulting in the sample/s requiring a dilution.

Explosives in water: PQLs raised as the sample matrix required dilution.

Ming To

From:	David Springer
Sent:	Wednesday, 14 December 2022 2:18 PM
To:	Customer Service
Subject:	FW: Regulated waste: review of initial results for RPM and wash water
Attachments:	RSImage.png; RSImage.png; RSImage.png; RSImage.png; RSImage.png; RSImage.png; RSImage.png; 311229-COC.pdf
Categories:	Additional

Ref: 311229-A
TAT: Standard
Due: 05/01/2022
MT

Can you please book in an 'A' job.

311229 – 1
311229 – 3
for all the solid tests from original job.
Due date 5th Jan please.

I will crush the samples and give to extractions.

Can the waters be saved and not disposed for future testing please.

Thanks

Kind Regards,

David Springer | Commercial Manager | Envirolab Services

Great Science. Great Service.

12 Ashley Street Chatswood NSW 2067
T 612 9910 6200 | M 0400 884 967
E DSpringer@envirolab.com.au | W www.envirolab.com.au

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Latest Update: Our Melbourne lab's NATA accredited for EDTA in soil and water matrices & compliant with EPA Victoria's

Please consider the environment before printing this email.

Merry Christmas and Happy New Year from Envirolab Services Sydney!
We will be closed from Fri 23 Dec, please submit urgent samples by Fri 16 Dec for results before Christmas.

Important Dates

Fri, 16 Dec	Last day to submit urgent samples for results before Christmas.
Fri, 23 Dec:	**CLOSED.** We will be closed all public holidays (Mon, 26 Dec. - Tue, 27 Dec.)
Wed, 28 Dec –	**OPEN.**

Fri, 30 Dec:	We will be operating with a skeleton staff (9:00am-5:00pm).
Mon, 2 Jan 2023:	**CLOSED.**
Tue, 3 Jan:	**OPEN.** Our laboratory will return to normal hours (7:00am – 6:00pm). Support offices will remain closed until Mon, 9 Jan.

More information on closure and return to standard hours by office and laboratory location

Samples will be analysed per our T&C's.

311229-A

From: Ruth Jarman <ruth@enrisks.com.au>
Sent: Wednesday, 14 December 2022 1:09 PM
To: David Springer <DSpringer@envirolab.com.au>
Cc: Jackie Wright <jackie@enrisks.com.au>; Christine.Howland@arrb.com.au; Darren G Wilson <darren.g.wilson@tmr.qld.gov.au>; Robert Urquhart <robert.urquhart@arrb.com.au>
Subject: FW: Regulated waste: review of initial results for RPM and wash water

CAUTION: This email originated from outside of the organisation. Do not act on instructions, click links or open attachments unless you recognise the sender and know the content is authentic and safe.

Hi David,

Can we please proceed with the analysis of the 2 remaining RPM samples for ARRB (Toowoomba and Gold Coast).

Can we please hold on the analysis for the 2 remaining wash water samples for now (no analysis, however if you could please hang onto these samples that would be great). Unfortunately PFAS was detected in the wash water sample so we need to re-group and work out where to with this waste next year.

Can the report and invoice for the additional RPM samples please be sent direct to Christine at ARRB (by cc on this e-mail) (cc us as well if you like). The enRiskS office will be closed from Friday 16 December 2022 until Thursday 5 January 2023.

Many thanks for all your help on this project, and wishing you and your team and family a very happy Christmas and New Year period.

Cheers,

Ruth Jarman

Environmental Risk Sciences Pty Ltd (enRiskS)
Mobile: +61 447 084 439 (Melbourne)
In the office Monday, Tuesday, Thursday and Friday
Email: ruth@enrisks.com.au

The office is closing on Friday 16 December 2022 and re-opens on Thursday 5 January 2023.

From: Christine Howland <Christine.Howland@arrb.com.au>
Sent: Wednesday, 14 December 2022 9:28 AM
To: Ruth Jarman <ruth@enrisks.com.au>
Cc: Jackie Wright <jackie@enrisks.com.au>; Robert Urquhart <robert.urquhart@arrb.com.au>; darren.g.wilson

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customerservice@envirolab.com.au
www.envirolab.com.au

SAMPLE RECEIPT ADVICE

Client Details

Client	enRiskS
Attention	Christine Howland, Ruth Jarman

Sample Login Details

Your reference	enRiskS - NACOE031
Envirolab Reference	311229-A
Date Sample Received	21/11/2022
Date Instructions Received	14/12/2022
Date Results Expected to be Reported	05/01/2023

Sample Condition

Samples received in appropriate condition for analysis	Yes
No. of Samples Provided	additional analysis
Turnaround Time Requested	Standard
Temperature on Receipt (°C)	12
Cooling Method	Ice Pack
Sampling Date Provided	YES

Comments

Nil

Please direct any queries to:

Aileen Hie	Jacinta Hurst
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Invoice will be emailed separately. Results will be reported only if payment has been made. Details of analysis on the following page:

Sample ID	MAH's in soil	vTRH(C6-C10)/BTEXN in Soil	svTRH (C10-C40) in Soil	PAHs in Soil	Speciated Phenols in Soil	Misc Soil - Inorg	Misc Inorg - Soil	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Copper	Lead	Mercury	Molybdenum	Nickel	Selenium	Silver	Vanadium	Zinc	On Hold
RPM Gold Coast	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Rockhampton RPM																								✓
RPM Toowoomba	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DSW1																								✓
DSW2																								✓
DSW3																								✓

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info

Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.

Requests for longer term sample storage must be received in writing.

Please contact the laboratory immediately if observed settled sediment present in water samples is to be included in the extraction and/or analysis (exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS analysis where solids are included by default.

TAT for Micro is dependent on incubation. This varies from 3 to 6 days.

Envirolab Services Pty Ltd
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12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 311229-A

Client Details

Client	enRiskS
Attention	Christine Howland, Ruth Jarman
Address	PO Box 2537, Carlingford Court, NSW, 2118

Sample Details

Your Reference	**enRiskS - NACOE031**
Number of Samples	additional analysis
Date samples received	21/11/2022
Date completed instructions received	14/12/2022

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	05/01/2023
Date of Issue	17/01/2023

This document shall not be reproduced except in full.

Results Approved By
Josh Williams, Organics and LC Supervisor
Kyle Gavrily, Senior Chemist
Liam Timmins, Organic Instruments Team Leader
Loren Bardwell, Development Chemist
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

MAH's in soil			
Our Reference		311229-A-1	311229-A-3
Your Reference	UNITS	RPM Gold Coast	RPM Toowoomba
Date Sampled		8/11/2022	17/11/2022
Type of sample		Solid	Solid
Date extracted	-	15/12/2022	15/12/2022
Date analysed	-	16/12/2022	16/12/2022
Benzene	mg/kg	<0.2	0.4
Toluene	mg/kg	<0.5	<0.5
Ethylbenzene	mg/kg	<1	2
m+p-xylene	mg/kg	<2	<2
o-Xylene	mg/kg	<1	<1
styrene	mg/kg	<1	3
isopropylbenzene	mg/kg	<1	<1
n-propyl benzene	mg/kg	<1	<1
1,3,5-trimethyl benzene	mg/kg	<1	<1
tert-butyl benzene	mg/kg	<1	<1
1,2,4-trimethyl benzene	mg/kg	<1	<1
sec-butyl benzene	mg/kg	<1	<1
4-isopropyl toluene	mg/kg	<1	<1
n-butyl benzene	mg/kg	<1	<1
Surrogate Dibromofluorometha	%	102	112
Surrogate aaa-Trifluorotoluene	%	122	114
Surrogate Toluene-d_8	%	100	103
Surrogate 4-Bromofluorobenzene	%	101	103

vTRH(C6-C10)/BTEXN in Soil			
Our Reference		311229-A-1	311229-A-3
Your Reference	UNITS	RPM Gold Coast	RPM Toowoomba
Date Sampled		8/11/2022	17/11/2022
Type of sample		Solid	Solid
Date extracted	-	15/12/2022	15/12/2022
Date analysed	-	16/12/2022	16/12/2022
TRH C_6 - C_9	mg/kg	<25	68
TRH C_6 - C_{10}	mg/kg	<25	80
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	<25	77
Benzene	mg/kg	<0.2	0.4
Toluene	mg/kg	<0.5	<0.5
Ethylbenzene	mg/kg	<1	2
m+p-xylene	mg/kg	<2	<2
o-Xylene	mg/kg	<1	<1
Naphthalene	mg/kg	<1	<1
Total +ve Xylenes	mg/kg	<1	<1
Surrogate aaa-Trifluorotoluene	%	122	114

svTRH (C10-C40) in Soil			
Our Reference		311229-A-1	311229-A-3
Your Reference	UNITS	RPM Gold Coast	RPM Toowoomba
Date Sampled		8/11/2022	17/11/2022
Type of sample		Solid	Solid
Date extracted	-	15/12/2022	15/12/2022
Date analysed	-	21/12/2022	21/12/2022
TRH C_{10} - C_{14}	mg/kg	<500	1,200
TRH C_{15} - C_{28}	mg/kg	5,700	2,700
TRH C_{29} - C_{36}	mg/kg	9,200	1,200
Total +ve TRH (C10-C36)	mg/kg	15,000	5,100
TRH >C_{10} -C_{16}	mg/kg	<500	1,300
TRH >C_{10} - C_{16} less Naphthalene (F2)	mg/kg	<500	1,300
TRH >C_{16} -C_{34}	mg/kg	13,000	3,300
TRH >C_{34} -C_{40}	mg/kg	7,700	1,400
Total +ve TRH (>C10-C40)	mg/kg	20,000	6,000
Surrogate o-Terphenyl	%	#	#

PAHs in Soil			
Our Reference		311229-A-1	311229-A-3
Your Reference	UNITS	RPM Gold Coast	RPM Toowoomba
Date Sampled		8/11/2022	17/11/2022
Type of sample		Solid	Solid
Date extracted	-	15/12/2022	15/12/2022
Date analysed	-	22/12/2022	22/12/2022
Naphthalene	mg/kg	<2.0	<2.0
Acenaphthylene	mg/kg	<2.0	<2.0
Acenaphthene	mg/kg	<2.0	<2.0
Fluorene	mg/kg	<2.0	<2.0
Phenanthrene	mg/kg	<2.0	<2.0
Anthracene	mg/kg	<2.0	<2.0
Fluoranthene	mg/kg	<2.0	<2.0
Pyrene	mg/kg	<2.0	<2.0
Benzo(a)anthracene	mg/kg	<2.0	<2.0
Chrysene	mg/kg	<2.0	<2.0
Benzo(b,j+k)fluoranthene	mg/kg	<4.0	<4.0
Benzo(a)pyrene	mg/kg	<1.0	<1.0
Indeno(1,2,3-c,d)pyrene	mg/kg	<2.0	<2.0
Dibenzo(a,h)anthracene	mg/kg	<2.0	<2.0
Benzo(g,h,i)perylene	mg/kg	<2.0	<2.0
Total +ve PAH's	mg/kg	<1	<1
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<10	<10
Benzo(a)pyrene TEQ calc(half)	mg/kg	<10	<10
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<10	<10
Surrogate p-Terphenyl-d14	%	#	#

Speciated Phenols in Soil			
Our Reference		311229-A-1	311229-A-3
Your Reference	UNITS	RPM Gold Coast	RPM Toowoomba
Date Sampled		8/11/2022	17/11/2022
Type of sample		Solid	Solid
Date extracted	-	15/12/2022	15/12/2022
Date analysed	-	22/12/2022	22/12/2022
Phenol	mg/kg	<4.0	28
2-Chlorophenol	mg/kg	<4.0	<4.0
4-Chloro-3-methylphenol	mg/kg	<20	<20
2-Methylphenol (o-cresol)	mg/kg	<4.0	<4.0
3/4-Methylphenol (m/p-cresol)	mg/kg	<8.0	<8.0
2-Nitrophenol	mg/kg	<4.0	<4.0
2,4 -Dimethylphenol	mg/kg	<4.0	<4.0
2,4-Dichlorophenol	mg/kg	<4.0	<4.0
2,6-Dichlorophenol	mg/kg	<4.0	<4.0
2,4,5-Trichlorophenol	mg/kg	<4.0	<4.0
2,4,6-Trichlorophenol	mg/kg	<4.0	<4.0
2,4-Dinitrophenol	mg/kg	<80	<80
4-Nitrophenol	mg/kg	<80	<80
2346-Tetrachlorophenol	mg/kg	<4.0	<4.0
2-methyl-4,6-Dinitrophenol	mg/kg	<40	<40
Pentachlorophenol	mg/kg	<20	<20
Surrogate 2-fluorophenol	%	#	#
Surrogate Phenol-d_6	%	#	#
Surrogate 2,4,6-Tribromophenol	%	#	#
Surrogate *p*-Terphenyl-d_{14}	%	#	#

Misc Soil - Inorg			
Our Reference		311229-A-1	311229-A-3
Your Reference	UNITS	RPM Gold Coast	RPM Toowoomba
Date Sampled		8/11/2022	17/11/2022
Type of sample		Solid	Solid
Date prepared	-	19/12/2022	19/12/2022
Date analysed	-	19/12/2022	19/12/2022
Hexavalent Chromium, Cr^{6+}	mg/kg	<1	<1

Misc Inorg - Soil			
Our Reference		311229-A-1	311229-A-3
Your Reference	UNITS	RPM Gold Coast	RPM Toowoomba
Date Sampled		8/11/2022	17/11/2022
Type of sample		Solid	Solid
Date prepared	-	03/01/2023	03/01/2023
Date analysed	-	03/01/2023	03/01/2023
pH 1:5 soil:water	pH Units	10.2	9.0

Acid Extractractable metals in soil			
Our Reference		311229-A-1	311229-A-3
Your Reference	UNITS	RPM Gold Coast	RPM Toowoomba
Date Sampled		8/11/2022	17/11/2022
Type of sample		Solid	Solid
Date prepared	-	22/12/2022	22/12/2022
Date analysed	-	28/12/2022	28/12/2022
Antimony	mg/kg	<7	<7
Arsenic	mg/kg	<4	<4
Barium	mg/kg	2	<1
Beryllium	mg/kg	<1	<1
Boron	mg/kg	<3	<3
Cadmium	mg/kg	<0.4	<0.4
Chromium	mg/kg	4	<1
Copper	mg/kg	23	<1
Lead	mg/kg	1	<1
Mercury	mg/kg	<0.1	<0.1
Molybdenum	mg/kg	<1	<1
Nickel	mg/kg	2	<1
Selenium	mg/kg	<2	<2
Silver	mg/kg	<1	<1
Vanadium	mg/kg	5	<1
Zinc	mg/kg	13	<1

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis. Note, the Total +ve TRH PQL is reflective of the lowest individual PQL and is therefore "Total +ve TRH" is simply a sum of the positive individual TRH fractions (>C10-C40).
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS and/or GC-MS/MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'EQ PQL'values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'EQ zero'values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'EQ half PQL'values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore "Total +ve PAHs" is simply a sum of the positive individual PAHs.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

Method ID	Methodology Summary
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater. Note, the Total +ve Xylene PQL is reflective of the lowest individual PQL and is therefore "Total +ve Xylenes" is simply a sum of the positive individual Xylenes.

Client Reference: enRiskS - NACOE031

QUALITY CONTROL: MAH's in soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-2	311229-A-3
Date extracted	-			15/12/2022	1	15/12/2022	15/12/2022		15/12/2022	15/12/2022
Date analysed	-			16/12/2022	1	16/12/2022	16/12/2022		16/12/2022	16/12/2022
Benzene	mg/kg	0.2	Org-023	<0.2	1	<0.2	<0.2	0	112	120
Toluene	mg/kg	0.5	Org-023	<0.5	1	<0.5	<0.5	0	105	121
Ethylbenzene	mg/kg	1	Org-023	<1	1	<1	<1	0	81	71
m+p-xylene	mg/kg	2	Org-023	<2	1	<2	<2	0	88	98
o-Xylene	mg/kg	1	Org-023	<1	1	<1	<1	0	88	96
styrene	mg/kg	1	Org-023	<1	1	<1	1	0	[NT]	[NT]
isopropylbenzene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
n-propyl benzene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
1,3,5-trimethyl benzene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
tert-butyl benzene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
1,2,4-trimethyl benzene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
sec-butyl benzene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
4-isopropyl toluene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
n-butyl benzene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
Surrogate Dibromofluorometha	%		Org-023	102	1	102	101	1	96	103
Surrogate aaa-Trifluorotoluene	%		Org-023	116	1	122	119	2	113	122
Surrogate Toluene-d_8	%		Org-023	98	1	100	99	1	105	105
Surrogate 4-Bromofluorobenzene	%		Org-023	102	1	101	99	2	106	108

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-2	311229-A-3
Date extracted	-			15/12/2022	1	15/12/2022	15/12/2022		15/12/2022	15/12/2022
Date analysed	-			16/12/2022	1	16/12/2022	16/12/2022		16/12/2022	16/12/2022
TRH C_6 - C_9	mg/kg	25	Org-023	<25	1	<25	<25	0	95	102
TRH C_6 - C_{10}	mg/kg	25	Org-023	<25	1	<25	<25	0	95	102
Benzene	mg/kg	0.2	Org-023	<0.2	1	<0.2	<0.2	0	112	120
Toluene	mg/kg	0.5	Org-023	<0.5	1	<0.5	<0.5	0	105	121
Ethylbenzene	mg/kg	1	Org-023	<1	1	<1	<1	0	81	71
m+p-xylene	mg/kg	2	Org-023	<2	1	<2	<2	0	88	98
o-Xylene	mg/kg	1	Org-023	<1	1	<1	<1	0	88	96
Naphthalene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
Surrogate aaa-Trifluorotoluene	%		Org-023	116	1	122	119	2	113	122

QUALITY CONTROL: svTRH (C10-C40) in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-2	311229-A-3
Date extracted	-			19/12/2022	1	15/12/2022	15/12/2022		15/12/2022	15/12/2022
Date analysed	-			20/12/2022	1	21/12/2022	21/12/2022		21/12/2022	21/12/2022
TRH C_{10} - C_{14}	mg/kg	50	Org-020	<50	1	<500	<500	0	118	#
TRH C_{15} - C_{28}	mg/kg	100	Org-020	<100	1	5700	4800	17	113	#
TRH C_{29} - C_{36}	mg/kg	100	Org-020	<100	1	9200	8600	7	88	#
TRH $>C_{10}$ -C_{16}	mg/kg	50	Org-020	<50	1	<500	<500	0	118	#
TRH $>C_{16}$ -C_{34}	mg/kg	100	Org-020	<100	1	13000	11000	17	113	#
TRH $>C_{34}$ -C_{40}	mg/kg	100	Org-020	<100	1	7700	7700	0	88	#
Surrogate o-Terphenyl	%		Org-020	81	1	#	#		86	#

QUALITY CONTROL: PAHs in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-2	[NT]
Date extracted	-			15/12/2022	1	15/12/2022	15/12/2022		15/12/2022	[NT]
Date analysed	-			22/12/2022	1	22/12/2022	22/12/2022		22/12/2022	[NT]
Naphthalene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	114	[NT]
Acenaphthylene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	116	[NT]
Fluorene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	121	[NT]
Phenanthrene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	122	[NT]
Anthracene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	120	[NT]
Pyrene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	126	[NT]
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	78	[NT]
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	<0.05	1	<1.0	<1.0	0	124	[NT]
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	<0.1	1	<2.0	<2.0	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	91	1	#	#		85	[NT]

QUALITY CONTROL: Speciated Phenols in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-2	[NT]
Date extracted	-			22/12/2022	1	15/12/2022	15/12/2022		22/12/2022	[NT]
Date analysed	-			22/12/2022	1	22/12/2022	22/12/2022		22/12/2022	[NT]
Phenol	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	100	[NT]
2-Chlorophenol	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	104	[NT]
4-Chloro-3-methylphenol	mg/kg	1	Org-022/025	<1	1	<20	<20	0	[NT]	[NT]
2-Methylphenol (o-cresol)	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	101	[NT]
3/4-Methylphenol (m/p-cresol)	mg/kg	0.4	Org-022/025	<0.4	1	<8.0	<8.0	0	[NT]	[NT]
2-Nitrophenol	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	[NT]	[NT]
2,4 -Dimethylphenol	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	[NT]	[NT]
2,4-Dichlorophenol	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	[NT]	[NT]
2,6-Dichlorophenol	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	140	[NT]
2,4,5-Trichlorophenol	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	[NT]	[NT]
2,4,6-Trichlorophenol	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	[NT]	[NT]
2,4-Dinitrophenol	mg/kg	4	Org-022/025	<4	1	<80	<80	0	[NT]	[NT]
4-Nitrophenol	mg/kg	4	Org-022/025	<4	1	<80	<80	0	72	[NT]
2346-Tetrachlorophenol	mg/kg	0.2	Org-022/025	<0.2	1	<4.0	<4.0	0	[NT]	[NT]
2-methyl-4,6-Dinitrophenol	mg/kg	2	Org-022/025	<2	1	<40	<40	0	[NT]	[NT]
Pentachlorophenol	mg/kg	1	Org-022/025	<1	1	<20	<20	0	108	[NT]
Surrogate 2-fluorophenol	%		Org-022/025	101	1	#	#		97	[NT]
Surrogate Phenol-d_6	%		Org-022/025	105	1	#	#		101	[NT]
Surrogate 2,4,6-Tribromophenol	%		Org-022/025	102	1	#	#		100	[NT]
Surrogate *p*-Terphenyl-d_{14}	%		Org-022/025	91	1	#	#		85	[NT]

QUALITY CONTROL: Misc Soil - Inorg					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-2	[NT]
Date prepared	-			19/12/2022	1	19/12/2022	19/12/2022		19/12/2022	[NT]
Date analysed	-			19/12/2022	1	19/12/2022	19/12/2022		19/12/2022	[NT]
Hexavalent Chromium, Cr^{6+}	mg/kg	1	Inorg-024	<1	1	<1	<1	0	108	[NT]

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			03/01/2023	[NT]	[NT]	[NT]	[NT]	03/01/2023	[NT]
Date analysed	-			03/01/2023	[NT]	[NT]	[NT]	[NT]	03/01/2023	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	99	[NT]

QUALITY CONTROL: Acid Extractractable metals in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	311229-A-3
Date prepared	-			22/12/2022	1	22/12/2022	22/12/2022		22/12/2022	22/12/2022
Date analysed	-			28/12/2022	1	28/12/2022	28/12/2022		28/12/2022	28/12/2022
Antimony	mg/kg	7	Metals-020	<7	1	<7	<7	0	97	96
Arsenic	mg/kg	4	Metals-020	<4	1	<4	<4	0	101	122
Barium	mg/kg	1	Metals-020	<1	1	2	2	0	107	112
Beryllium	mg/kg	1	Metals-020	<1	1	<1	<1	0	98	110
Boron	mg/kg	3	Metals-020	<3	1	<3	<3	0	100	112
Cadmium	mg/kg	0.4	Metals-020	<0.4	1	<0.4	<0.4	0	108	105
Chromium	mg/kg	1	Metals-020	<1	1	4	3	29	104	113
Copper	mg/kg	1	Metals-020	<1	1	23	21	9	103	124
Lead	mg/kg	1	Metals-020	<1	1	1	<1	0	105	114
Mercury	mg/kg	0.1	Metals-021	<0.1	1	<0.1	<0.1	0	76	83
Molybdenum	mg/kg	1	Metals-020	<1	1	<1	<1	0	109	107
Nickel	mg/kg	1	Metals-020	<1	1	2	2	0	108	113
Selenium	mg/kg	2	Metals-020	<2	1	<2	<2	0	90	111
Silver	mg/kg	1	Metals-020	<1	1	<1	<1	0	80	103
Vanadium	mg/kg	1	Metals-020	<1	1	5	4	22	101	116
Zinc	mg/kg	1	Metals-020	<1	1	13	13	0	128	109

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

TRH Soil C10-C40 NEPM - # Percent recovery for the surrogate/matrix spike is not possible to report as the high concentration of analytes in samples 311229-A-1,1D,3MS have caused interference.
TRH Soil C10-C40 NEPM - The PQL for 311229-A -1 has been raised due to the sample matrix thereby requiring a dilution.

pH

Samples were out of the recommended holding time for this analysis.

Speciated Phenols/PAH in Soil - The PQL for 311229-1,3 has been raised due to the sample matrix thereby requiring a dilution.

Speciated Phenols/PAH in Soil - # Percent recovery for the surrogate is not possible to report due to interference from analytes (other than those being tested) in samples 311229-1,3.

Ming To

Subject: FW: ARRB RPM analysis
Attachments: Aust Road Research Board enRisk_22SY408_rev2.pdf

Ref: 311229-B.
TAT: Standard
Due: 19/09/2023
MT

From: Ruth Jarman <ruth@enrisks.com.au>
Sent: Thursday, 12 January 2023 11:11 AM
To: David Springer <DSpringer@envirolab.com.au>
Cc: Jackie Wright <jackie@enrisks.com.au>; Christine.Howland@arrb.com.au; Darren G Wilson <darren.g.wilson@tmr.qld.gov.au>; Robert Urquhart <robert.urquhart@arrb.com.au>
Subject: ARRB RPM analysis

Hi David,

Happy New Year!

①-③

Can you please proceed with the ASLP (neutral pH) testing for all 3 RPM samples for the ARRB project? Can we please have ASLP analysis for the following:

- Toluene, ethylbenzene, styrene.
- Naphthalene.
- Phenol.
- Copper.
- Vanadium.
- TRH (an addition to the attached quote).

We also seem to be missing the silica gel clean up analysis for the Rockhampton RPM in COA 311229? Could you please send these results through when available? Confirming we need silica gel clean up analysis for the Gold Coast and Toowoomba RPM samples.

Cheers,

Ruth Jarman

Environmental Risk Sciences Pty Ltd (enRiskS)
Mobile: +61 447 084 439 (Melbourne)
In the office Monday, Tuesday, Thursday and Friday
ruth@enrisks.com.au

From: Ruth Jarman
Sent: Wednesday, 14 December 2022 1:09 PM
To: David Springer <DSpringer@envirolab.com.au>
Cc: Jackie Wright <jackie@enrisks.com.au>; Christine.Howland@arrb.com.au; Darren G Wilson <darren.g.wilson@tmr.qld.gov.au>; Robert Urquhart <robert.urquhart@arrb.com.au>
Subject: FW: Regulated waste: review of initial results for RPM and wash water

Hi David,

Can we please proceed with the analysis of the 2 remaining RPM samples for ARRB (Toowoomba and Gold Coast).

Can we please hold on the analysis for the 2 remaining wash water samples for now (no analysis, however if you could please hang onto these samples that would be great). Unfortunately PFAS was detected in the wash water sample so we need to re-group and work out where to with this waste next year.

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200   fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

SAMPLE RECEIPT ADVICE

Client Details

Client	enRiskS
Attention	Christine Howland, Ruth Jarman

Sample Login Details

Your reference	enRiskS - NACOE031
Envirolab Reference	311229-B
Date Sample Received	21/11/2022
Date Instructions Received	12/01/2023
Date Results Expected to be Reported	03/02/2023

Sample Condition

Samples received in appropriate condition for analysis	Holding time exceedance
No. of Samples Provided	additional analysis
Turnaround Time Requested	Standard
Temperature on Receipt (°C)	12
Cooling Method	Ice Pack
Sampling Date Provided	YES

Comments

Please contact the laboratory within 24 hours if you wish to cancel the aformentioned testing. Otherwise testing will proceed as per the COC and hence invoiced accordingly.

Please direct any queries to:

Aileen Hie	Jacinta Hurst
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Invoice will be emailed separately. Results will be reported only if payment has been made. Details of analysis on the following page:

Sample ID	sTPH in Soil (C10-C40)-Silica	ASLP ZHE Preparation - Neutral	vTRH(C6-C10)/BTEXN Zero Headspace ASLP	ASLP Preparation - Neutral	sTRH in water leach	Speciated Phenols in ASLP	Metals from Neutral Leaching Fluid ICPMS	On Hold
RPM Gold Coast	✓	✓	✓	✓	✓	✓	✓	
Rockhampton RPM	✓	✓	✓	✓	✓	✓	✓	
RPM Toowoomba	✓	✓	✓	✓	✓	✓	✓	
DSW1								✓
DSW2								✓
DSW3								✓
RPM Gold Coast - [TRIPLICATE]								✓

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info

Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.

Requests for longer term sample storage must be received in writing.

Please contact the laboratory immediately if observed settled sediment present in water samples is to be included in the extraction and/or analysis (exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS analysis where solids are included by default.

TAT for Micro is dependent on incubation. This varies from 3 to 6 days.

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200   fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 311229-B

Client Details

Client	enRiskS
Attention	Christine Howland, Ruth Jarman
Address	PO Box 2537, Carlingford Court, NSW, 2118

Sample Details

Your Reference	**enRiskS - NACOE031**
Number of Samples	additional analysis
Date samples received	21/11/2022
Date completed instructions received	12/01/2023

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	03/02/2023
Date of Issue	25/01/2023

NATA Accreditation Number 2901. This document shall not be reproduced except in full.

Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Hannah Nguyen, Metals Supervisor
Josh Williams, Organics and LC Supervisor
Liam Timmins, Organic Instruments Team Leader
Steven Luong, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

svTRH (C10-C40) in Soil				
Our Reference		311229-B-1	311229-B-2	311229-B-3
Your Reference	UNITS	RPM Gold Coast	Rockhampton RPM	RPM Toowoomba
Date Sampled		8/11/2022	7/11/2022	17/11/2022
Type of sample		Solid	Solid	Solid
Date extracted	-	18/01/2023	18/01/2023	18/01/2023
Date analysed	-	18/01/2023	18/01/2023	18/01/2023
TRH C_{10} - C_{14}	mg/kg	<500	<500	<500
TRH C_{15} - C_{28}	mg/kg	4,800	1,600	3,800
TRH C_{29} - C_{36}	mg/kg	9,700	3,300	1,900
Total +ve TRH (C10-C36)	mg/kg	14,000	4,900	5,700
TRH >C_{10} -C_{16}	mg/kg	<500	<500	<500
TRH >C_{16} -C_{34}	mg/kg	12,000	3,700	4,200
TRH >C_{34} -C_{40}	mg/kg	7,800	4,400	2,500
Total +ve TRH (>C10-C40)	mg/kg	20,000	8,100	6,700
Surrogate o-Terphenyl	%	#	#	#

sTPH in Soil (C10-C40)-Silica				
Our Reference		311229-B-1	311229-B-2	311229-B-3
Your Reference	UNITS	RPM Gold Coast	Rockhampton RPM	RPM Toowoomba
Date Sampled		8/11/2022	7/11/2022	17/11/2022
Type of sample		Solid	Solid	Solid
Date extracted	-	16/01/2023	16/01/2023	16/01/2023
Date analysed	-	17/01/2023	17/01/2023	17/01/2023
TPH C_{10} - C_{14}	mg/kg	<500	<500	<500
TPH C_{15} - C_{28}	mg/kg	4,300	1,700	2,000
TPH C_{29} - C_{36}	mg/kg	8,500	3,500	1,800
TPH >C_{10} -C_{16}	mg/kg	<500	<500	<500
TPH >C_{16} -C_{34}	mg/kg	10,000	3,900	3,000
TPH >C_{34} -C_{40}	mg/kg	6,600	4,500	2,500
Surrogate o-Terphenyl	%	117	125	124

ASLP ZHE Preparation - Neutral				
Our Reference		311229-B-1	311229-B-2	311229-B-3
Your Reference	UNITS	RPM Gold Coast	Rockhampton RPM	RPM Toowoomba
Date Sampled		8/11/2022	7/11/2022	17/11/2022
Type of sample		Solid	Solid	Solid
pH of final Leachate	pH units	8.0	7.3	7.7

vTRH(C6-C10)/BTEXN Zero Headspace ASLP				
Our Reference		311229-B-1	311229-B-2	311229-B-3
Your Reference	UNITS	RPM Gold Coast	Rockhampton RPM	RPM Toowoomba
Date Sampled		8/11/2022	7/11/2022	17/11/2022
Type of sample		Solid	Solid	Solid
Date extracted	-	18/01/2023	18/01/2023	18/01/2023
Date analysed	-	19/01/2023	19/01/2023	19/01/2023
TRH C_6 - C_9	µg/L	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10
Benzene	µg/L	1	<1	3
Toluene	µg/L	<1	<1	2
Ethylbenzene	µg/L	<1	<1	2
m+p-xylene	µg/L	<2	<2	<2
o-xylene	µg/L	<1	<1	<1
Styrene	µg/L	6	4	5
Naphthalene	µg/L	<1	<1	<1
Surrogate Dibromofluoromethane	%	104	116	111
Surrogate toluene-d8	%	99	107	103
Surrogate 4-BFB	%	110	111	110

ASLP Preparation - Neutral				
Our Reference		311229-B-1	311229-B-2	311229-B-3
Your Reference	UNITS	RPM Gold Coast	Rockhampton RPM	RPM Toowoomba
Date Sampled		8/11/2022	7/11/2022	17/11/2022
Type of sample		Solid	Solid	Solid
pH of final Leachate	pH units	5.2	9.5	9.4

sTRH in water leach				
Our Reference		311229-B-1	311229-B-2	311229-B-3
Your Reference	UNITS	RPM Gold Coast	Rockhampton RPM	RPM Toowoomba
Date Sampled		8/11/2022	7/11/2022	17/11/2022
Type of sample		Solid	Solid	Solid
Date extracted	-	18/01/2023	18/01/2023	18/01/2023
Date analysed	-	18/01/2023	18/01/2023	18/01/2023
TRH C_{10} - C_{14}	µg/L	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100
Surrogate o-Terphenyl	%	85	92	100

PAHs in water leach				
Our Reference		311229-B-1	311229-B-2	311229-B-3
Your Reference	UNITS	RPM Gold Coast	Rockhampton RPM	RPM Toowoomba
Date Sampled		8/11/2022	7/11/2022	17/11/2022
Type of sample		Solid	Solid	Solid
Date extracted	-	18/01/2023	18/01/2023	18/01/2023
Date analysed	-	19/01/2023	19/01/2023	19/01/2023
Naphthalene in ASLP	mg/L	<0.001	<0.001	<0.001
Acenaphthylene in ASLP	mg/L	<0.001	<0.001	<0.001
Acenaphthene in ASLP	mg/L	<0.001	<0.001	<0.001
Fluorene in ASLP	mg/L	<0.001	<0.001	<0.001
Phenanthrene in ASLP	mg/L	<0.001	<0.001	<0.001
Anthracene in ASLP	mg/L	<0.001	<0.001	<0.001
Fluoranthene in ASLP	mg/L	<0.001	<0.001	<0.001
Pyrene in ASLP	mg/L	<0.001	<0.001	<0.001
Benzo(a)anthracene in ASLP	mg/L	<0.001	<0.001	<0.001
Chrysene in ASLP	mg/L	<0.001	<0.001	<0.001
Benzo(bjk)fluoranthene in ASLP	mg/L	<0.002	<0.002	<0.002
Benzo(a)pyrene in ASLP	mg/L	<0.001	<0.001	<0.001
Indeno(1,2,3-c,d)pyrene - ASLP	mg/L	<0.001	<0.001	<0.001
Dibenzo(a,h)anthracene in ASLP	mg/L	<0.001	<0.001	<0.001
Benzo(g,h,i)perylene in ASLP	mg/L	<0.001	<0.001	<0.001
Surrogate p-Terphenyl-d_{14}	%	63	74	81

Speciated Phenols in ASLP				
Our Reference		311229-B-1	311229-B-2	311229-B-3
Your Reference	UNITS	RPM Gold Coast	Rockhampton RPM	RPM Toowoomba
Date Sampled		8/11/2022	7/11/2022	17/11/2022
Type of sample		Solid	Solid	Solid
Date extracted	-	18/01/2023	18/01/2023	18/01/2023
Date analysed	-	19/01/2023	19/01/2023	19/01/2023
Phenol in TCLP	ug/L	<1	<1	<1
2-Chlorophenol in TCLP	ug/L	<1	<1	<1
4-Chloro-3-Methylphenol in TCLP	ug/L	<5	<5	<5
2-Methylphenol (0-Cresol) in TCLP	ug/L	<1	<1	<1
3/4-Methylphenol (m/p-Cresol) in TCLP	ug/L	<2	<2	<2
2-Nitrophenol in TCLP	ug/L	<1	<1	<1
2,4-Dimethylphenol in TCLP	ug/L	<1	<1	<1
2,4-Dichlorophenol in TCLP	ug/L	<1	<1	<1
2,6-Dichlorophenol in TCLP	ug/L	<1	<1	<1
2,4,5-Trichlorophenol in TCLP	ug/L	<1	<1	<1
2,4,6-Trichlorophenol in TCLP	ug/L	<1	<1	<1
2,4-Dinitrophenol in TCLP	ug/L	<20	<20	<20
4-Nitrophenol in TCLP	ug/L	<20	<20	<20
2346-Tetrachlorophenol in TCLP	ug/L	<1	<1	<1
2-methyl-4,6-Dinitrophenol in TCLP	ug/L	<10	<10	<10
Pentachlorophenol in TCLP	ug/L	<5	<5	<5
Surrogate 2-fluorophenol	%	43	49	55
Surrogate Phenol-d_6	%	32	33	41
Surrogate 2,4,6-Tribromophenol	%	57	65	70
Surrogate *p*-Terphenyl-d_{14}	%	63	74	81

Metals from Neutral Leaching Fluid ICPMS				
Our Reference		311229-B-1	311229-B-2	311229-B-3
Your Reference	UNITS	RPM Gold Coast	Rockhampton RPM	RPM Toowoomba
Date Sampled		8/11/2022	7/11/2022	17/11/2022
Type of sample		Solid	Solid	Solid
Date extracted	-	18/01/2023	18/01/2023	18/01/2023
Date analysed	-	18/01/2023	18/01/2023	18/01/2023
Copper	µg/L	6	1	<1
Vanadium	µg/L	<1	<1	<1

Method ID	Methodology Summary
Inorg-004	Toxicity Characteristic Leaching Procedure (TCLP) using AS 4439 and USEPA 1311. Please note that the mass used may be scaled down from default based on sample mass available. Samples are stored at 2-6oC before and after leachate preparation.
Metals-022	Determination of various metals by ICP-MS following leaching using ultra high purity water, i.e. reagent water = CLASS 1, 2 & 4 from AS 4439.3.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis. Note, the Total +ve TRH PQL is reflective of the lowest individual PQL and is therefore "Total +ve TRH" is simply a sum of the positive individual TRH fractions (>C10-C40).
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS.
Org-022/025 ASLP	ASLP Leachates are extracted with Dichloromethane and analysed by GC-MS/GC-MSMS.
Org-023	Water samples are analysed directly by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

QUALITY CONTROL: svTRH (C10-C40) in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-7	
Date extracted	-			18/01/2023	[NT]	[NT]	[NT]	[NT]	18/01/2023	[NT]
Date analysed	-			18/01/2023	[NT]	[NT]	[NT]	[NT]	18/01/2023	[NT]
TRH C_{10} - C_{14}	mg/kg	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	94	[NT]
TRH C_{15} - C_{28}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	73	[NT]
TRH C_{29} - C_{36}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	86	[NT]
TRH $>C_{10}$ - C_{16}	mg/kg	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	94	[NT]
TRH $>C_{16}$ - C_{34}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	73	[NT]
TRH $>C_{34}$ - C_{40}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	86	[NT]
Surrogate o-Terphenyl	%		Org-020	100	[NT]	[NT]	[NT]	[NT]	97	[NT]

QUALITY CONTROL: sTPH in Soil (C10-C40)-Silica					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-7	[NT]
Date extracted	-			17/01/2023	[NT]	[NT]	[NT]	[NT]	16/01/2023	[NT]
Date analysed	-			17/01/2023	[NT]	[NT]	[NT]	[NT]	16/01/2023	[NT]
TPH C_{10} - C_{14}	mg/kg	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	85	[NT]
TPH C_{15} - C_{28}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	120	[NT]
TPH C_{29} - C_{36}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	88	[NT]
TPH $>C_{10}$ -C_{16}	mg/kg	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	85	[NT]
TPH $>C_{16}$ -C_{34}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	120	[NT]
TPH $>C_{34}$ -C_{40}	mg/kg	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	88	[NT]
Surrogate o-Terphenyl	%		Org-020	105	[NT]	[NT]	[NT]	[NT]	88	[NT]

QUALITY CONTROL: vTRH(C6-C10)/BTEXN Zero Headspace ASLP					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			18/01/2023	1	18/01/2023	19/01/2023		18/01/2023	[NT]
Date analysed	-			19/01/2023	1	19/01/2023	20/01/2023		19/01/2023	[NT]
TRH C_6 - C_9	µg/L	10	Org-023	<10	1	<10	<10	0	112	[NT]
TRH C_6 - C_{10}	µg/L	10	Org-023	<10	1	<10	<10	0	112	[NT]
Benzene	µg/L	1	Org-023	<1	1	1	1	0	102	[NT]
Toluene	µg/L	1	Org-023	<1	1	<1	<1	0	101	[NT]
Ethylbenzene	µg/L	1	Org-023	<1	1	<1	<1	0	119	[NT]
m+p-xylene	µg/L	2	Org-023	<2	1	<2	<2	0	120	[NT]
o-xylene	µg/L	1	Org-023	<1	1	<1	<1	0	117	[NT]
Styrene	µg/L	1	Org-023	<1	1	6	6	0	[NT]	[NT]
Naphthalene	µg/L	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	107	1	104	119	13	105	[NT]
Surrogate toluene-d8	%		Org-023	100	1	99	107	8	98	[NT]
Surrogate 4-BFB	%		Org-023	113	1	110	112	2	109	[NT]

QUALITY CONTROL: vTRH(C6-C10)/BTEXN Zero Headspace ASLP					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-			[NT]	3	18/01/2023	19/01/2023		[NT]	[NT]
Date analysed	-			[NT]	3	19/01/2023	20/01/2023		[NT]	[NT]
TRH C_6 - C_9	µg/L	10	Org-023	[NT]	3	<10	<10	0	[NT]	[NT]
TRH C_6 - C_{10}	µg/L	10	Org-023	[NT]	3	<10	<10	0	[NT]	[NT]
Benzene	µg/L	1	Org-023	[NT]	3	3	1	100	[NT]	[NT]
Toluene	µg/L	1	Org-023	[NT]	3	2	<1	67	[NT]	[NT]
Ethylbenzene	µg/L	1	Org-023	[NT]	3	2	<1	67	[NT]	[NT]
m+p-xylene	µg/L	2	Org-023	[NT]	3	<2	<2	0	[NT]	[NT]
o-xylene	µg/L	1	Org-023	[NT]	3	<1	<1	0	[NT]	[NT]
Styrene	µg/L	1	Org-023	[NT]	3	5	6	18	[NT]	[NT]
Naphthalene	µg/L	1	Org-023	[NT]	3	<1	<1	0	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	[NT]	3	111	119	7	[NT]	[NT]
Surrogate toluene-d8	%		Org-023	[NT]	3	103	107	4	[NT]	[NT]
Surrogate 4-BFB	%		Org-023	[NT]	3	110	112	2	[NT]	[NT]

QUALITY CONTROL: sTRH in water leach					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date extracted	-			18/01/2023	[NT]	[NT]	[NT]	[NT]	18/01/2023	[NT]
Date analysed	-			18/01/2023	[NT]	[NT]	[NT]	[NT]	18/01/2023	[NT]
TRH C_{10} - C_{14}	µg/L	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	68	[NT]
TRH C_{15} - C_{28}	µg/L	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	88	[NT]
TRH C_{29} - C_{36}	µg/L	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	100	[NT]
TRH >C_{10} - C_{16}	µg/L	50	Org-020	<50	[NT]	[NT]	[NT]	[NT]	68	[NT]
TRH >C_{16} - C_{34}	µg/L	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	88	[NT]
TRH >C_{34} - C_{40}	µg/L	100	Org-020	<100	[NT]	[NT]	[NT]	[NT]	100	[NT]
Surrogate o-Terphenyl	%		Org-020	103	[NT]	[NT]	[NT]	[NT]	108	[NT]

QUALITY CONTROL: PAHs in water leach					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date extracted	-			18/01/2023	[NT]	[NT]	[NT]	[NT]	18/01/2023	[NT]
Date analysed	-			19/01/2023	[NT]	[NT]	[NT]	[NT]	19/01/2023	[NT]
Naphthalene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	105	[NT]
Acenaphthylene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Acenaphthene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	119	[NT]
Fluorene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	118	[NT]
Phenanthrene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	126	[NT]
Anthracene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluoranthene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	125	[NT]
Pyrene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	133	[NT]
Benzo(a)anthracene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chrysene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	83	[NT]
Benzo(bjk)fluoranthene in ASLP	mg/L	0.002	Org-022/025 ASLP	<0.002	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(a)pyrene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	122	[NT]
Indeno(1,2,3-c,d)pyrene - ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibenzo(a,h)anthracene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(g,h,i)perylene in ASLP	mg/L	0.001	Org-022/025 ASLP	<0.001	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-d_{14}	%		Org-022/025 ASLP	82	[NT]	[NT]	[NT]	[NT]	85	[NT]

QUALITY CONTROL: Speciated Phenols in ASLP						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date extracted	-			18/01/2023	[NT]	[NT]	[NT]	[NT]	18/01/2023	[NT]
Date analysed	-			19/01/2023	[NT]	[NT]	[NT]	[NT]	19/01/2023	[NT]
Phenol in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	47	[NT]
2-Chlorophenol in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	93	[NT]
4-Chloro-3-Methylphenol in TCLP	ug/L	5	Org-022/025	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-Methylphenol (0-Cresol) in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	90	[NT]
3/4-Methylphenol (m/p-Cresol) in TCLP	ug/L	2	Org-022/025	<2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-Nitrophenol in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4-Dimethylphenol in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4-Dichlorophenol in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,6-Dichlorophenol in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	110	[NT]
2,4,5-Trichlorophenol in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4,6-Trichlorophenol in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2,4-Dinitrophenol in TCLP	ug/L	20	Org-022/025	<20	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
4-Nitrophenol in TCLP	ug/L	20	Org-022/025	<20	[NT]	[NT]	[NT]	[NT]	41	[NT]
2346-Tetrachlorophenol in TCLP	ug/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
2-methyl-4,6-Dinitrophenol in TCLP	ug/L	10	Org-022/025	<10	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Pentachlorophenol in TCLP	ug/L	5	Org-022/025	<5	[NT]	[NT]	[NT]	[NT]	101	[NT]
Surrogate 2-fluorophenol	%		Org-022/025	56	[NT]	[NT]	[NT]	[NT]	55	[NT]
Surrogate Phenol-d_6	%		Org-022/025	42	[NT]	[NT]	[NT]	[NT]	38	[NT]
Surrogate 2,4,6-Tribromophenol	%		Org-022/025	67	[NT]	[NT]	[NT]	[NT]	71	[NT]
Surrogate *p*-Terphenyl-d_{14}	%		Org-022/025	82	[NT]	[NT]	[NT]	[NT]	85	[NT]

QUALITY CONTROL: Metals from Neutral Leaching Fluid ICPMS					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date extracted	-			18/01/2023	[NT]	[NT]	[NT]	[NT]	18/01/2023	[NT]
Date analysed	-			18/01/2023	[NT]	[NT]	[NT]	[NT]	18/01/2023	[NT]
Copper	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	95	[NT]
Vanadium	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	93	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Samples received in good order: Holding time exceedance

TRH_S: # Percent recovery for the surrogate is not possible to report as the high concentration of analytes in sample 311229-b-1-3 have caused interference.

Appendix C Protected environmental values

This review of risk issues considers the protected environmental values (EV) of groundwater and surface water under the Queensland Government Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (DES 2019).

EVs are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses, and require protection from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. Different waters may have different EVs. Where more than one EV applies to a given water, the adoption of the most stringent water quality objective (WQO) for the identified EVs applies to each water quality indicator to protect all identified EVs. The selection of EVs for waters does not mean that these are currently free of toxicants (including bioaccumulative toxicants).

Protected EVs vary depending on the catchment and include:

- aquatic ecosystems – default EV for all Queensland waters comprising:
    - high ecological/conservation value waters
    - slightly disturbed waters
    - moderately disturbed waters
    - highly disturbed waters
- irrigation – water that, when used in accordance with the best irrigation and crop management practices and principles of ecologically sustainable development, does not result in crop yield loss or soil degradation
- farm supply – water provided for farm use is suitable for produce preparation and for domestic household uses other than drinking
- stock water – water provided to stock watering does not cause deterioration in stock health or condition
- aquaculture – water protective of the health of aquaculture species and humans consuming aquatic foods from commercial ventures
- human consumer (including oystering) – water produces aquatic food that is fit for human consumption and does not cause deterioration in human health
- primary recreation and visual recreation – water that presents a low risk to human health from water quality threats posed by exposure through ingestion, inhalation or contact during recreational use of water
- drinking water – water that when taken for treatment for human consumption:
    - minimises the risk of adverse human health effects
    - maintains the palatability rating of water at the level of ‘good’ as set out in the Australian Drinking Water Guidelines (ADWG)
    - minimises the risk that the odour of drinking water being offensive to consumers.
- industrial use – water that is suitable for use, with an appropriate (usually industry specific) level of treatment
- cultural and spiritual values – water that remains fit for purpose in relation to cultural, spiritual and ceremonial values and uses of water.

As the catchment where the waste RPM may be re-used is not known, all protected EVs have been considered in this HHERA.

The most sensitive EVs are aquatic ecosystems and drinking water (i.e. potable water use). The other protected EVs are not expected to be affected by concentrations of chemicals sourced from the waste RPM or are considered protected where the aquatic ecosystems and potable water use EV are protected. These EV which have not been considered further in the HHERA, are (with the relevant rationale):

- irrigation, farm supply and stock water – protected by potable water use
- human consumption of aquatic foods and aquaculture – protected by potable water use
- primary recreation and visual recreation – protected by potable water use
- industrial use – protected by potable water use
- cultural and spiritual values – protected by potable water use and water dependant ecosystems and species.

The protection of the some of the above EV by the assumption that groundwater and/or surface water is used for potable water use is based on the adoption of the ADWG (NHMRC 2011 updated 2022).

The ADWG are concentrations which, based on present knowledge, do not result in any significant risk to the health of a consumer of the water over a lifetime. They apply at the point of extraction and indicate the concentrations of chemicals in water that are considered to be safe for "*human consumption, either directly, as supplied from the tap, or indirectly, in beverages, ice or foods prepared with water. Drinking water is also used for other domestic purposes such as bathing and showering*". The methodology used to derive the guidelines allows for exposures other than ingestion, including dermal contact and inhalation of volatiles during activities such as showering in heated water.

Hence, the ADWG have been derived in a manner that allows for all exposures considered likely to occur during home use of water, including use of water for washing, food preparation, irrigation of gardens etc. It is considered that assuming consumption of 2L/day is sufficient to cover for the exposure pathway which people would be exposed to every day for their whole life. The drinking water guidelines also assume that only 10% of a person's exposure to the chemical comes from drinking water (90% is assumed to come from other pathways). From an overall perspective, the ADWG represents the concentration of a chemical in water that the Australian Government has determined is safe to drink and use for any purpose commonly undertaken for domestic purposes for a lifetime. Hence, where concentrations of chemicals are below drinking water guidelines, the use of this water for all uses including potable water supply, recreational use (e.g. swimming), irrigation of crops and stock watering is considered suitable.

The ANZG (2018) for chemicals (specifically toxicants) in water have been adopted for the protection of the aquatic ecosystems EV. As the catchment where the waste RPM may be re-used is not known, the 99% protection values for largely unmodified aquatic ecosystems have been adopted. This is the most conservative protection level for aquatic ecosystems and will be an overly conservative approach for most waterways in Queensland.

Appendix B Sampling Instructions

YOUR NATIONAL
TRANSPORT RESEARCH
ORGANISATION

2nd November 2022

Darren Wilson
Roadtek Branch, Infrastructure Management and Delivery Division
Department of Transport and Main Roads
Ground Floor, Coombabah Depot, Banyula Drive, Nerang Qld 4211

Dear Darren

Subject: NACoE 031 – Sampling Instructions for laboratory analysis of Paint Wash water and Raised Pavement Markers (RPMs)

The following simplified sampling instructions have been prepared to provide guidance on the correct sampling techniques to be utilised for obtaining samples for the NACoE 031 project. These instructions have been prepared based on the recommended analysis detailed in the Regulated Waste Technical Review: Reducing waste from raised pavement markers and wash waters derived from line marking paint, as prepared by EnRiskS (31 October 2022).

The following instructions have been prepared with consideration of the requirements outlined in the following:

- DES (2018), Monitoring and Sampling Manual.
- *Environmental Protection Act 1994.*
- *Environmental Protection Regulation 2019.*
- National Environmental Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM) (as amended 2013).

1. Raised Pavement Markers (RPMs)

Three (3) samples, comprising ten (10) RPMs per sample, are to be collected and submitted to the laboratory for analysis for potential contaminants of concern. One sample will be collected per site from the Rockhampton, Toowoomba and the Gold Coast facilities.

The RPMs for the sample should be selected so that they contain a typical amount of binder adhesive. Due to the nature of the material being sampled, RPMs can be collected in a generic large zip lock bag (or similar) for submission to the laboratory.

Please see below instructions for sample collection.

- Ensure the sample collection bags are new/clean to ensure no cross contamination.
- Label sample bags with a permanent marker prior to collecting the RPM samples.
  - Project: NACoE031
  - Sample ID: e.g. RPM-Rockhampton
  - Date: Date of sampling
  - Sampled By: Initials of sampler
- Note down specific details of the sampling location and/or material being sampled. e.g. Sample collected from storage bin of RPMs collected on the 20/10/22.
- Take photos of the sample, storage containers and facility. Please forward notes and photographs through to Christine.howland@arrb.com.au.

- Chilled storage of samples is not required for the RPMs.

2. Paint Wash Water

Three (3) samples from paint wash water to be disposed of require collection for analysis. All three (3) samples will be collected from the Toowoomba site. Where possible, samples should be collected from different containers holding wash water generated on different dates. For each sample, the 14 laboratory supplied sample bottles (as shown in Figure 1) will need to be filled entirely.

Figure 1 Paint Wash Water Sampling Containers

Please see below instructions for sample collection:

- Wear a fresh pair of powder free nitrile gloves for each sampling location to avoid cross contamination.
- Label sample containers with a permanent marker prior to collecting the paint wash water samples.
  - Project: NACoE031
  - Sample ID: e.g. WW-01-date (include date of generation of wash water or any other beneficial identifying markers)
  - Date: Date of sampling
  - Sampled By: Initials of sampler
- Fill each bottle completely so there is no airspace remaining.
  - Be careful not to overfill. This may result in any preservative present in the bottle being displaced.
- Any equipment utilised in collecting the sample should be cleaned and rinsed in between samples to avoid any potential cross-contamination.
- Note down specific details of the sampling location and/or material being sampled. E.g. Sample collected from wash water generated on the 20/10/22, stored in an IBC (approximately 500L of wash water stored).
- Take photos of the sampled liquid, storage containers and facility. Please forward notes and photographs through to Christine.howland@arrb.com.au.

- Upon collection of samples, place the filled bottles into a chilled esky ready for submission to the laboratory.
- Samples should be couriered to ARRB (refer section 3 below) as soon as possible (within 24 hours) upon collection.
- Varying holding times apply.

3. Sample Delivery

As the samples will be collected from multiple locations, please have the three (3) RPM samples and the three (3) paint wash water samples sent directly to ARRB for collation and preparation of the laboratory's Chain of Custody (COC).

Address details:

Attn: Christine Howland (M:0499 850 115)

ARRB

21 McLachlan Street, Fortitude Valley Qld 4006

Yours Sincerely

Christine Howland
Senior Technology Leader, Environmental Management
Sustainability and Material Performance