Administrative Report

Review of health-based guideline values for Per- and Polyfluoroalkyl Substances (PFAS) in the *Australian Drinking Water Guidelines*

October 2024 – Public consultation draft

Contents

Administrative Report: Review of health-based guideline values for Per- and Polyfluoroalkyl Substances (PFAS) in the *Australian Drinking Water Guidelines*

Summary

The National Health and Medical Research Council (NHMRC) has updated guidance in the *Australian Drinking Water Guidelines* (the Guidelines) regarding the per- and polyfluoroalkyl substances (PFAS) fact sheet, including revised and newly established health-based guideline values. NHMRC has also developed a Statement on PFAS in drinking water, which provides a summary of the findings that informed the update to the draft PFAS fact sheet.

The specific PFAS reviewed as part of this update include: perfluorooctanoic acid (PFOA); perfluorooctane sulfonic acid (PFOS); perfluorohexane sulfonic acid (PFHxS); perfluorobutane sulfonic acid (PFBS); hexafluoropropylene oxide dimer acid and its ammonium salt (GenX chemicals).

NHMRC's review has resulted in lower health-based guideline values for PFOA and PFOS based on health concerns. New, separate health-based guideline values for PFHxS and PFBS have also been established. A health-based guideline value for GenX chemicals is not currently considered necessary.

This document summarises the development process for drafting the updated guidance on PFAS in Australian drinking water.

Background

NHMRC issues guidelines under section 7(1) of the *National Health and Medical Research Council Act 1992* (the Act). NHMRC is responsible for the *Australian Drinking Water Guidelines* (2011) (the Guidelines), which undergoes a rolling revision to ensure they represent the latest scientific evidence on good quality drinking water. The Guidelines provide guidance to water regulators and suppliers on monitoring and managing drinking water quality. They are intended to provide a framework for the good management of drinking water supplies that if implemented will assure safety at the point of use.

The Guidelines form part of the National Water Quality Management Strategy, an Australian Government initiative in partnership with state and territory governments. The Guidelines are intended as a consistent source of authoritative guidance on drinking water quality management and allows state and territory governments to adapt the guidance to local needs.

Part V of the Guidelines contains fact sheets for chemicals that are typically present in Australian drinking water supplies. The fact sheets contain information on relevant aspects of the chemicals in drinking water, including but not limited to:

- health-related advice (e.g. a health-based guideline value and/or public health advice, health considerations, exposure information and risk summaries)

- supporting information (e.g. guidance on analytical measurements or sampling, water treatment and risk management options).

Since the current version of the Guidelines was published in 2011, updates to specific sections of the Guidelines, including chemical fact sheets, have been undertaken as part of a 'rolling review' process. Suggestions for potential updates or the development of new advice are considered in response to new evidence, stakeholder needs and available resources. Updates are prioritised and delivered with advice from the Water Quality Advisory Committee (the Committee).

PFAS Health-based Guideline Values

PFAS are a group of over four thousand manufactured chemicals that do not occur naturally in the environment. Humans can be exposed to PFAS present in food, consumer products, dust and drinking water. The major sources of PFAS are expected to be food and consumer products, however, the proportion of exposure from drinking water can increase in individuals living in areas with drinking water containing PFAS.

In August 2018 NHMRC published health-based guideline values for three per- and polyfluoroalkyl substances (PFAS) (PFOS + PFHxS and PFOA) in Australian drinking water. These guideline values were based on a tolerable daily intake (TDI), developed by Food Standards Australia New Zealand (FSANZ) which refers to the daily amount of a chemical that has been assessed as safe for humans on a long-term basis (FSANZ 2017).

A number of changes to international advice for PFAS have been published since NHMRC published the 2018 PFAS fact sheet. For example, in September 2020, the European Food Safety Authority (EFSA) set a new safety threshold for the main PFAS that accumulate in the body (EFSA 2020). In June 2022, the United States Environmental Protection Agency (US EPA) issued interim drinking water health advisories for two types of PFAS (PFOS and PFOA), which were lower than the Australian health-based guideline values for drinking water (US EPA 2022). Two new PFAS drinking water health advisories for PFBS and GenX chemicals were also issued. Since then, the US EPA has issued a Final PFAS National Primary Drinking Water Regulation for six PFAS.

It is not uncommon for guideline values to vary from country to country due to different methodologies and calculations, the choice of endpoints used and expressions of units. However, as the United States and European advisory levels were lower than the current Australian values for drinking water, some concern had been raised about whether the current Australian drinking water guideline values for PFAS adequately protect consumers against the health effects of PFAS.

In response to these new advisories and growing community concerns, NHMRC prioritised a review of the Australian health-based guideline values for PFAS (PFOS, PFHxS and PFOA), including consideration of GenX chemicals and PFBS in late 2022. The review aimed to determine whether a change to NHMRC advice is warranted or not.

This report describes the process undertaken to review the PFAS fact sheet and public health advice for PFOS, PFHxS, PFOA, PFBS and GenX chemicals in drinking water.

Development of updated draft PFAS Fact Sheet

Methodological framework

As part of a broader organisational effort to improve the processes used to develop NHMRC guidelines, NHMRC designed a streamlined methodological framework (the Framework) to guide the rolling revision of chemical fact sheets in the Guidelines.

The Framework is intended to provide greater consistency and alignment with the 2016 *NHMRC Standards for Guidelines* and international best practice in evidence review methods and guideline development. It is also intended to:

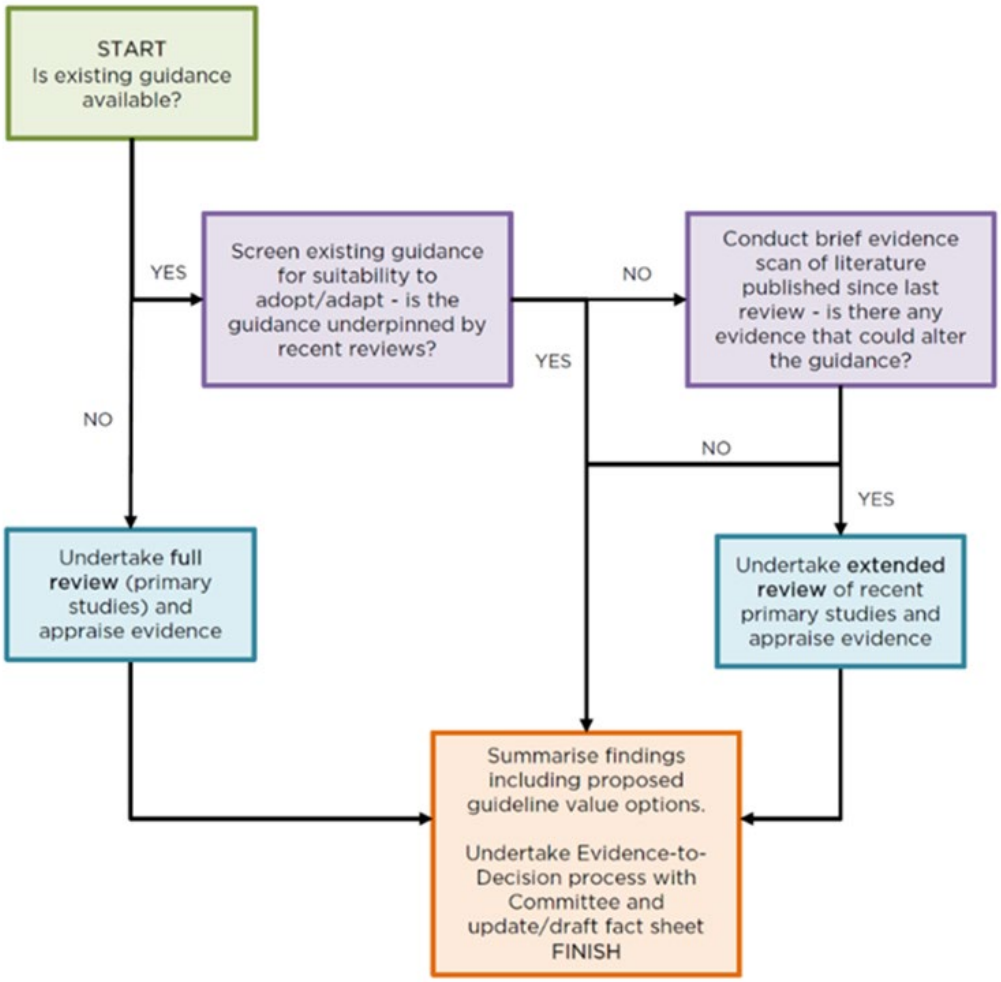
- make efficient use of limited project resources (e.g. funding, team and Committee capacity)
- make greater use of recent reviews undertaken by other jurisdictions and reduce duplication of effort
- minimise the timeframes required to undertake a chemical fact sheet review (depending on whether recent reviews are available)
- allow a more responsive approach to changes in international guidance
- allow more reviews to be undertaken in-house using templates and tools
- help inform future funding bids by identifying chemicals that may require additional funding for contracted evidence reviews.

The Framework provides the option to undertake different levels of review depending on the available evidence (see **Figure 1**). The Framework outlines a staged approach that preferences a transparent adopt/adapt process for evaluating existing health advice (such as international health-based guideline values) in the first instance instead of undertaking a more comprehensive review of primary studies. Other features of the Framework include:

- the option to undertake an evidence scan to check for emerging evidence of concern since the existing guideline was published (if it was not reviewed recently)
- the option to undertake reanalysis of key study findings from existing guidelines if appropriate and advised by the Committee
- the flexibility to customise the review process for each chemical using template research protocols for the different levels of review.

Existing guidance for a chemical may not always be available or appropriate to use for the Australian context. In these cases, a full review of recent primary studies is required, and additional resources will be needed to undertake the review. Testing of the Framework as part of the rolling revision of the Guidelines has been underway since 2020.

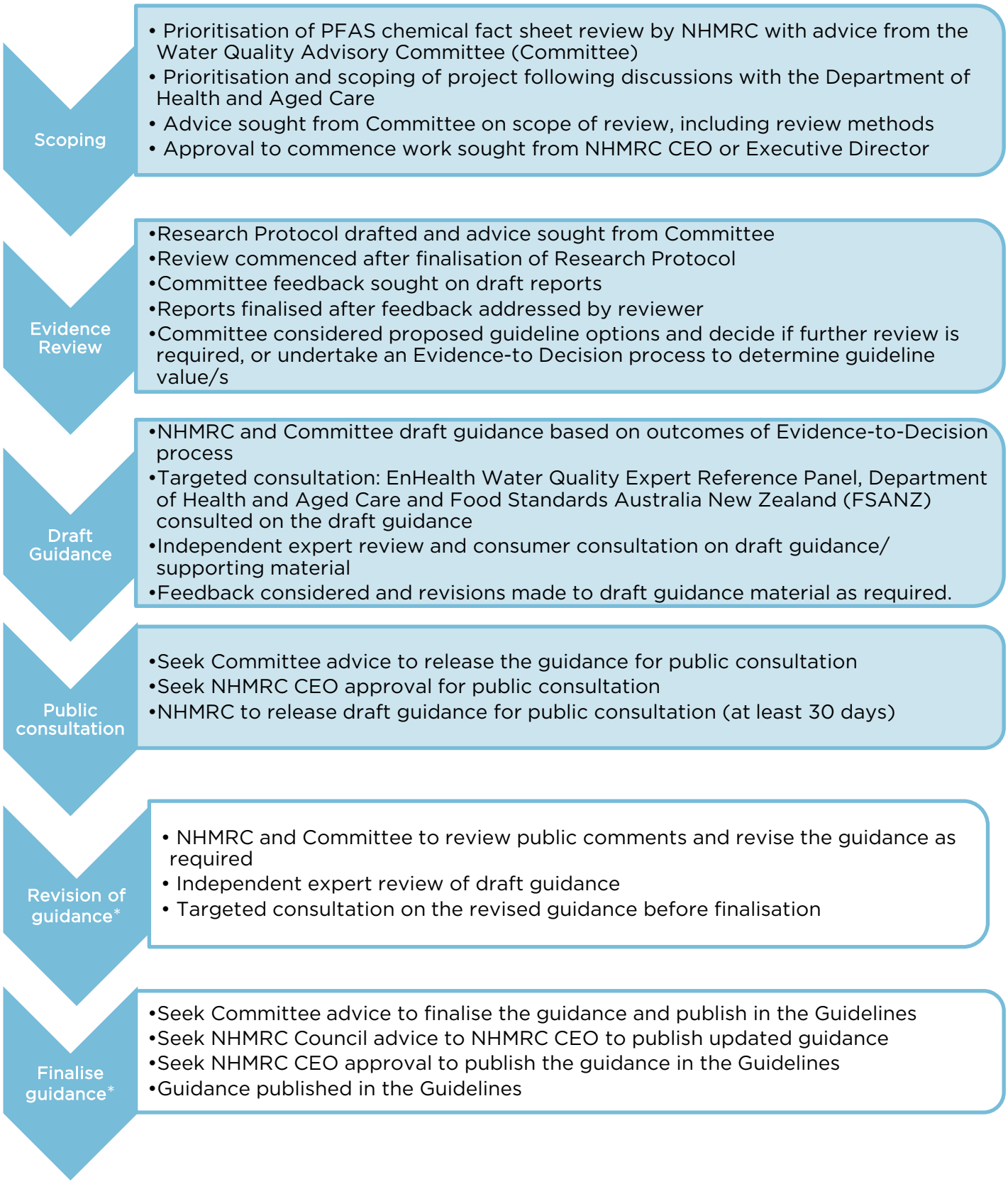
Figure 1: Simplified decision tree for undertaking evidence evaluation reviews using the Framework



As existing guidance and guidelines for PFAS underpinned by recent reviews were identified, an adopt/adapt process was considered suitable for the review of the PFAS fact sheet.

Key steps undertaken as part of the guidance development process for the PFAS fact sheet are summarised in **Figure 2**. This process is consistent with standard processes undertaken for the rolling revision of the Guidelines, NHMRC Standards for Guidelines and NHMRC internal guideline development processes.

Figure 2: Overview of current rolling review process for updating/developing chemical fact sheets using Framework (*to be completed)



Contracted evidence reviews

In April 2023, NHMRC contracted SLR Consulting Australia (SLR Consulting) to undertake an evidence review to evaluate existing evidence and underpinning studies of guidance and reviews available from national and international jurisdictions for five PFAS in drinking water: PFOA, PFOS, PFHxS, PFBS and Gen X Chemicals. The evidence review also included an evidence scan regarding PFAS levels detected in Australian drinking water and guidance on PFAS detection, monitoring and treatment. The evidence scan served to inform an update to the supporting information within the existing PFAS chemical Fact Sheet.

The reviewer applied the methodological framework as part of the evidence review by:

- customising a draft research protocol template provided by NHMRC. The research protocol outlines the review scope and parameters for searching, selecting and appraising the evidence.
- confirming any amendments to the draft research protocol with the Committee at a meeting. The Committee confirmed the research questions and other technical details required for the review.
- finalising the research protocol (and any amendments) and seeking approval from NHMRC before commencing the review.
- undertaking a review of evidence for each of the five PFAS chemicals as per the Framework (**Figure 1**), specifically that if recently published guidance/guidelines are available, assessing the methods used by the organisation/agency with an Assessment Tool provided by NHMRC that assesses administrative and technical criteria to determine if they are suitable to adopt/adapt
- undertaking an evidence scan to support the development or update of supporting information in the chemical fact sheet.
- derive candidate guideline options for each of the five PFAS in drinking water using Australian assumption values and uncertainty factors.
- presenting the findings of the review in an Evidence Evaluation and Technical Report for Committee consideration.

As part of scoping the review, a literature search of existing health-based guidance/ guidelines was completed. The volume of information found and needing to be assessed was very large. Due to resource constraints and to deliver the review within a reasonable time, the critical evaluation of studies underpinning existing guidelines values was prioritised with Committee support to those studies that had not been previously reviewed and/or considered by an Australian agency for guidance/guideline value development (such as in neither FSANZ 2017, 2021)).

Based on Committee advice the scope of the review was also amended to incorporate an additional critical appraisal of the key underpinning study of the current NHMRC health-based guideline value for PFOA (Lau *et al.* 2006), including how it was assessed and used to derive a guidance value by Burgoon *et al.* (2023). The Committee also advised that an expert determination of the certainty of this study relative to the other proposed guideline options should be undertaken.

The review did not make recommendations for specific health-based guideline values but provided candidate guideline options for consideration by the Committee. These options were based on

existing guidance/guidelines that were found suitable to adopt/adapt to the Australian context, with a critical discussion of the underlying key toxicological studies used by each agency to derive their guidance/guidelines.

The initial evidence review was completed by SLR Consulting in February 2024. Further details on how the evidence review was undertaken is provided in the Research Protocol, Evidence Evaluation and Technical Reports (SLR 2023; 2024a, b). The February Evidence Evaluation Report was revised in October 2024 by the reviewer, following consideration by SLR Consulting Australia of targeted consultation feedback. Details of amendments made to the report is outlined in the targeted consultation feedback table at **Appendix B.**

Addendum to the contracted evidence review

Since the finalisation of the initial contracted evidence review (SLR 2024a, b), the US EPA published their Final PFAS National Primary Drinking Water Regulation in April 2024 for a number of PFAS, including final toxicity assessments for PFOS and PFOA (US EPA 2024a, b). These reports included several key and candidate studies for PFOS and PFOA that had not previously been evaluated in the SLR (2024a, b) review nor by FSANZ (i.e. in neither FSANZ 2017, 2021).

NHMRC contracted SLR Consulting to undertake an additional evidence evaluation and prepare an Addendum Report which considers the key studies in the final US EPA toxicity assessments for PFOS and PFOA (US EPA 2024a, b), as well as another recently published peer-reviewed scientific paper by an international collaboration of scientists deriving guidance values for PFOA (Burgoon *et al*. 2023). SLR Consulting also undertook an assessment of the available methods, rationales and guidance used by other agencies to derive a total/sum of PFAS guideline value (i.e. a review of approaches for PFAS mixtures assessment in drinking water).

The updated evidence evaluation was undertaken in line with the same methodological framework as used in the initial SLR (2024a, b) review. The resulting options for candidate guideline values for PFOA and PFOS, as well as the findings of a review of approaches for assessing PFAS mixtures, were presented for consideration by the Committee (SLR 2024c). The additional review was completed by SLR Consulting in August 2024.

The August Addendum Report was revised in October 2024 by the reviewer, following consideration by SLR Consulting Australia of targeted consultation feedback. Details of amendments made to the report is outlined in the targeted consultation feedback table at **Appendix B**.

Evidence-to-Decision process

Evidence reviews provide a comprehensive summary of the evidence but do not include recommendations (e.g. health-based guideline values). The term 'decision' is used to mean the resulting judgement of the evidence made by NHMRC and the Committee. In March 2024, NHMRC, with advice from the Committee, developed draft Evidence-to-Decision tables for each PFAS based on the results of the initial Evidence Evaluation Reports (SLR 2024a, b) and relevant criteria from existing Evidence-to-Decision frameworks (e.g. GRADE and WHO-INTEGRATE frameworks as outlined in Alonso-Coello *et al.* (2016) and Rehfuess *et al.* (2019)). These tables were later updated with relevant health evidence from the Addendum Report (SLR 2024c) for consideration by the Committee.

The Evidence-to-Decision tables (**Appendix A**) helped to inform Committee discussion and support transparent consideration of the findings from the evidence reviews undertaken by the reviewer (e.g. evidence profiles for candidate guideline values), along with public health considerations such as values and preferences, equity, feasibility and resource impacts. Guideline recommendations were updated as required on the advice of the Committee based on information received through additional review and feedback from targeted consultation and expert review. As these are working documents used to guide Committee discussion and decision-making, they will be updated with relevant information received from public consultation submissions before the Committee makes a final decision before publication.

The Committee reviewed and considered the Evidence-to-Decision tables at the March, July and August 2024 meetings. Targeted consultation and independent expert review occurred in September (details below) which resulted in edits/corrections to the review reports by the contractor and changes to candidate guideline options for PFOS and PFOA. These were considered out of session by the Committee in October and final decisions were made on the draft guideline values for public consultation at a follow up meeting.

This process is summarised in **Table 1** below.

Table 1: Evidence to decision summary

March 2024 Water Quality Advisory Committee meeting	Members agreed: • that the contracted review and assessment of underlying studies for candidate guideline values (SLR 2024a, b) were of high quality and that they were comfortable with the conclusions drawn by the reviewer. • that the preferred option for PFOA is to maintain the current health-based guideline value of 560 ng/L based on developmental effects observed in mice (Lau *et al.* 2006) (*note this decision was superseded at the July 2024 Committee meeting*). • to maintain the current health-based guideline value of PFOS + PFHxS of 70 ng/L based on developmental effects observed in rats (Luebker *et al*. 2005), with PFHxS not exceeding 30 ng/L (rounded from 34 ng/L to 1 significant figure) based on thyroid effects observed in rats (NTP 2022)[1] (*note this decision was superseded at the July 2024 Committee meeting*). • to establish a new health-based guideline value for PFBS of 1000 ng/L, equivalent to 1 µg/L (rounded from 1107 mg/L to 1 significant figure) based on thyroid effects observed in mice (Feng *et al*. 2017). • to not establish a health-based guideline value for GenX chemicals. Members noted that given the limited evidence available, further

[1] Note that NTP (2022) is occasionally cited at NTP (2019) in SLR (2024 a,b,c). The NTP (2019) report has been revised since initial publication and updated in 2022 (NTP 2022). Minor revisions were made in NTP (2022) from the 2019 report version, all of which are marked up and identified in Appendix F of the NTP (2022) report.

	toxicological information would be needed before Members would be comfortable setting a health-based guideline value for GenX chemicals.
July 2024 Water Quality Advisory Committee meeting	Members agreed: • that the Addendum (SLR 2024c) was of high-quality and that they were comfortable with the revised conclusions for PFOS and PFOA drawn by the reviewer. • that the derivation of a health-based guideline value for PFOA using a threshold approach was appropriate, given that SLR (2024c) found that the overall weight of evidence is that PFOA is not genotoxic. • to adapt the NTP (2023)[2] study in the guideline derivation for PFOA, based on carcinogenicity in rats (pancreatic acinar adenomas and adenocarcinomas). Thus, a new health-based guideline value of 200 ng/L (rounded from 221 ng/L to 1 significant figure) was advised for PFOA. • to adapt the NTP (2022)[1] study in the guideline derivation for PFOS, based on thyroid effects in rats (i.e. decreased T4 and free T4 hormone levels). Thus, a new health-based guideline value of 4 ng/L (rounded from 4.2 ng/L to 1 significant figure) was advised for PFOS (*note this decision was superseded at the October 2024 Committee meeting*).
August 2024 Water Quality Advisory Committee meeting	Members discussed the updated Evidence to Decision Tables that included information from SLR (2024c) and agreed to review and endorse them in preparation for targeted consultation.
September 2024 Water Quality Advisory Committee meeting	Members discussed targeted consultation feedback received from the Department of Health and Aged Care, Food Standards Australia New Zealand (FSANZ) and the enHealth Water Quality Expert Reference Panel. Details on the issues raised and how these issues were addressed are provided in **Appendix B.** Representatives from FSANZ attended the meeting to raise concerns about the key studies used to derive health-based guideline values for PFOS and PFOA. FSANZ considers that: • these studies (NTP 2022[1] and NTP 2023[2]) do not provide sufficient scientific justification for changing the current health-based guideline values • the critical health effects proposed (thyroid effects) are likely to have limited toxicological relevance to humans, and that the established tolerable daily intakes (TDIs) for PFOS and PFOA, based on reproductive/development effects, remain appropriate.

[2] Note that NTP (2023) is occasionally cited as NTP (2020) in SLR (2024 a,b,c). The 2020 NTP report has been revised and updated in 2023 (NTP 2023). Minor revisions were made in NTP (2023) from the 2020 report version, all of which are marked up and identified in the NTP (2023) report.

	Members discussed the concerns raised around the toxicological basis, the choice of studies and endpoints and uncertainty factors in deriving the health-based guideline values. Members agreed: • the thyroid endpoint in the NTP (2022)[1] study should not be used to derive a health-based guideline value for PFOS due to the lack of clinical relevance of observed effects from rats to humans. • to consider the health-based guideline value for PFOA again after SLR Consulting provides further information about the human relevancy of pancreatic acinar adenomas and adenocarcinomas cited in the NTP (2023)[2] study.
October 2024 Water Quality Advisory Committee meeting	Members discussed the updated evidence reports and preliminary Committee decisions on potential health-based guideline values for PFOS and PFOA. They also confirmed all health-based guideline values for the public consultation draft PFAS guidance. Members agreed: • to adapt the NTP (2022)[1] study in the guideline derivation for **PFOS**, based on bone marrow effects (extramedullary haematopoiesis and bone marrow hypocellularity) as the critical health effect (endpoint). • that although there were substantial differences between the modelled Benchmark Dose Level (BMDL) approach and measured no observed adverse effect levels (NOAELs) (i.e. 29-fold difference in female rats and 5-fold difference in male rats), Members agreed that the former was a more statistically robust approach to use and results in a lower and more conservative guideline value for **PFOS** (i.e. 3.4 ng/L instead of 77 ng/L) than the NOAEL approach. Members noted that this is consistent with the US EPA (2024c), which also applied the BMDL approach when assessing the data from this study. Thus, a new health-based guideline value of 4 ng/L (rounded up from 3.4 ng/L to 1 significant figure) was advised for **PFOS**. • that although there are uncertainties about the clinical relevance of neoplastic pancreatic tumours in rats to humans, these findings could not be completely dismissed in light of in vitro studies that may support a relevant mode of action in humans. Given the classification of **PFOA** as a Group 1 carcinogen by IARC and the rating by US EPA (2024b) that the NTP (2023)[2] findings were from a high confidence study, Members agreed the neoplastic pancreatic effects observed in the high-quality NTP (2023)[2] study were an appropriately conservative point of departure to derive a health-based guideline value for **PFOA** of 200 ng/L (rounded from 227 ng/L to 1 significant figure). Members reconfirmed: • that the health-based guideline value for **PFHxS** should remain separate (i.e. not combined with PFOS) as there is sufficient

	toxicological information available to establish a new health-based guideline value for PFHxS of 30 ng/L (rounded from 34 ng/L to 1 significant figure), based on thyroid effects observed in rats (NTP 2022)[1]. • to establish a new health-based guideline value for PFBS of 1000 ng/L, equivalent to 1 µg/L (rounded from 1107 mg/L to 1 significant figure) based on thyroid effects observed in mice (Feng *et al*. 2017). • to not establish a health-based guideline value for GenX chemicals. At this meeting Members advised the CEO to release the draft guidance for public consultation.

Council Meeting June 2024

At its 232nd Session, the Council of NHMRC noted the increased media interest and community concern in response to the April 2024 US EPA PFAS advice and the delay in releasing updated Australian advice. To prevent further delays in delivering updated advice whilst maintaining rigour and confidence in the guideline review process, Council agreed to the following:

- under section 82(2)(b) of the *NHMRC Act 1992* to delegate, to the Water Quality Advisory Committee, Council's specific powers and functions under section 13 of the *NHMRC Act 1992* to provide guidelines to the CEO in respect of the PFAS guidelines including to prepare a draft of those guidelines, to publish a notice on the NHMRC website for the purpose of public consultation on those guidelines, and to consider submissions made in response.
- to advise the Water Quality Advisory Committee to have regard to the advice of the Chief Medical Officer and Chief Health Officers and consumer advisory group prior to issuing the draft PFAS guidance for public consultation.

Drafting of guidance

The NHMRC Project Team drafted an updated fact sheet for PFAS based on the February 2024 Evidence Evaluation Report and Technical Report, discussions with the Committee and the outcomes of the evidence-to-decision process at the March 2024 meeting. The Chemical Subgroup reviewed the draft guidance and provided feedback, before the full Committee reviewed and discussed the updated fact sheet at the May 2024 meeting.

The NHMRC Project Team updated the draft PFAS fact sheet based on the findings from the additional review (SLR 2024c), discussions with the Committee and outcomes of the evidence-to-decision process at the July 2024 meeting. The Chemical Subgroup and/or full Committee reviewed the draft guidance and provided feedback out of session or during discussion at committee meetings.

NHMRC, with Committee advice, drafted a NHMRC Statement to accompany the Fact Sheet. The purpose of the NHMRC Statement is to provide a high-level, plain language summary of the guideline values and focus on potential community concerns such as the critical health effects (particularly carcinogenicity of PFOA), and differences in Australian advice to the US EPA

approach. The draft Fact Sheet, the NHMRC Statement and supporting information underwent targeted consultation, with feedback sought from the enHealth Water Quality Expert Reference Panel, the Department of Health and Aged Care and FSANZ.

Revisions to the draft Fact Sheet and supporting documents to address feedback from targeted consultation were made with advice from the Committee feedback. SLR Consulting assisted in drafting responses to technical questions and made edits and corrections to the review reports as required before finalising for public consultation.

A timeline of the overall guideline development process, including key meetings where the project was discussed, is provided in **Table 2**.

Table 2 Timeline of the PFAS fact sheet review

Key guidance development steps	Date
Request from Department of Health and Aged Care for NHMRC to prioritise the review of Australian health-based guideline values for PFAS in drinking water.	October 2022
NHMRC Chief Executive Officer (CEO) approved NHMRC to review the Australian health-based guideline values for PFAS.	November 2022
Memorandum of Understanding with the Department of Health and Aged Care for NHMRC to review Australian health-based guideline values for PFAS in drinking water is signed by both agencies.	February 2023
SLR Consulting contracted to undertake an evidence review of existing PFAS guidance/ guidelines.	April 2023
Finalisation of research protocol by SLR Consulting with Committee consultation.	June 2023
Evidence review undertaken by SLR Consulting with draft reports provided to the Committee for comment.	September 2023
Scope of the evidence review amended with advice from the Committee.	December 2023
Finalisation of evidence review by SLR Consulting with draft reports reviewed by the Committee and comments addressed prior to acceptance by NHMRC.	February 2024
Committee consideration of guideline options and evidence-to-decision process for each PFAS.	March 2024

NHMRC drafted updated PFAS guidance with advice from the Committee Chemical Subgroup.	April 2024
Committee advice to undertake an updated evidence evaluation (Addendum to the SLR (2024a, b) review) to consider the April 2024 US EPA advice for PFOA and PFOS and key studies included in Burgoon *et al.* 2023 and options for a total/sum of PFAS value.	April 2024
Committee and Chemical Subgroup consideration of scope of additional review; NHMRC drafting of procurement documents and NHMRC Executive approval of additional PFAS review	May-June 2024
Review of draft guidance by the Committee (draft provided to the Council of NHMRC at its 232nd Session)	June 2024
SLR Consulting contracted to undertake additional evidence review. Draft Addendum Report provided to the Committee for comment. Committee consideration of draft Addendum findings and potential guideline options.	July - August 2024
NHMRC updated PFAS guidance with advice from the Committee	July – August 2024
Targeted consultation on draft updated guidance with EnHealth WQERP, the Department of Health and Aged Care and FSANZ and independent expert review	September 2024
Collation of targeted consultation feedback and revision to guidance as required with advice from the Committee	September - October 2024
Chief Medical Officer/Chief Health Officer and consumer representative consideration of draft guidance	October 2024
Committee advice to NHMRC CEO to release draft PFAS fact sheet for public consultation	October 2024
Public consultation open (minimum 30 days)	*October – November 2024
NHMRC and Committee review of submissions and revision to guidance as required	*December 2024 – January 2025
Independent expert review and targeted consultation on final guidance with EnHealth WQERP, Department of Health and Aged Care and FSANZ	*February 2025

Finalisation of guidance with advice from the Committee	*March 2025
Advice from NHMRC Council to publish final guidance in Guidelines	*March 2025
NHMRC CEO final approval to publish guidance in Guidelines	*April 2025
Publication of guidance in the *Australian Drinking Water Guidelines*	***April 2025**

*Anticipated dates (blue shading indicates tasks completed)
EnHealth WQERP – Environmental Health Standing Committee Water Quality Expert Reference Panel
FSANZ – Food Standards Australia New Zealand

Water Quality Advisory Committee advice

The NHMRC Water Quality Advisory Committee (the Committee) provides expert advice to NHMRC on public health issues related to drinking water quality. The primary role of the Committee is the rolling review of the Guidelines.

Following the Framework, the Committee provided advice at several meetings during different stages of the review and guideline development processes, including advice on:

- the draft Research Protocol for the evidence evaluation and scope of the additional evidence review
- the draft Evidence Evaluation and Technical Report and Addendum Report (initially through a subgroup of the Committee (the Chemical Subgroup) and then the full Committee)
- the candidate guideline options presented in the evidence review reports and evidence to decision tables
- the draft updated guidance (initially through the Chemical Subgroup and then full Committee)
- responses to address targeted consultation feedback
- final guideline values for public consultation and advice to the CEO to release the draft guidance for public consultation.

Targeted consultation

The Environmental Health Standing Committee (enHealth) Water Quality Expert Reference Panel provided expert feedback on the draft guidance in September 2024. Panel membership included jurisdictional representatives working in the field of drinking water quality and public health who can provide feedback on the feasibility and accuracy of NHMRC advice.

The Commonwealth Department of Health and Aged Care and FSANZ were also formally consulted on the draft guidance in September 2024 prior to public consultation.

A number of amendments to the draft guidance were made with advice from the Committee as a result of the feedback provided. Amendments were also made to the evidence review reports by

the contractor, SLR Consulting, as a result of feedback received during targeted consultation. Further details on the issues raised by the enHealth Water Quality Expert Reference Panel, the Department of Health and Aged Care and FSANZ on the draft guidance and evidence review reports and how these issues were addressed are provided in Appendix B.

Independent Expert Review

Independent expert review on the draft PFAS guidance was undertaken prior to public consultation. This was to provide an additional quality assurance step as advised by the Water Quality Advisory Committee. The purpose of expert review was to seek feedback on whether the evidence evaluation undertaken was sound and reliable and ensure that the evidence had been appropriately synthesised and interpreted. Potential expert reviewers were suggested by members of the Committee or identified by NHMRC for their expertise, particularly in the field of PFAS, water quality, toxicology or environmental health/human health risk assessment. Expert reviewers were required to complete a Disclosure of Interests and a Confidentiality Deed Poll, as per NHMRC standard processes.

Expert review prior to public consultation was undertaken by Adjunct Professor Brian Priestly from the School of Public Health and Preventive Medicine, Monash University. A summary of expert review comments is provided in Appendix C.

Key comments raised by the expert reviewer included:

- that the evidence reviewed is extensively covered with sufficient detail and analysis to provide confidence that the most appropriate studies, toxicological endpoints and methodologies for assessing new water quality guideline values have been used
- that the new proposed numbers for PFOA, PFOS, PFHxS and PFBS are well supported, appropriately conservative, and provide adequate health protection for Australian consumers of potable water
- support for using a threshold approach to Toxicity Reference Values (TRV) development for PFOA from a cancer endpoint since the evidence for PFAS genotoxicity is insufficient to support a non-threshold approach, however there are some reservations about the choice of a carcinogenicity endpoint for PFOA (pancreatic acinar adenomas and adenocarcinomas), rather than non-neoplastic hepatic, developmental or immunological endpoints
- comments relating to the human relevancy of the toxicological endpoint of modification of thyroid hormone status in rats, noting that the use of this thyroid endpoint remains appropriate for PFHxS and PFBS, despite the uncertainty about human relevance
- general comments relating to the selection of uncertainty factors and toxicokinetic adjustments and how these can affect guideline value calculations
- support for rejecting the immunomodulation response used for TRV development by EFSA, the US EPA and some other agencies (i.e. agreement with the position held by the evidence reviewer and FSANZ regarding immunomodulatory responses).

The expert review feedback supported a number of revisions to the review reports and was provided to the Water Quality Advisory Committee to consider when advising on guideline options for public consultation.

Further expert review is anticipated to take place during public consultation and later drafts of the guidance following public consultation.

Consumer consultation

The Council of NHMRC advised at its 232nd Session that consumer representatives should be consulted prior to releasing the draft guidance for public consultation. Three members of the NHMRC-MRFF Interim Consumer Advisory Network (Ms Ainslie Cahill, Ms Christine Gunson and Adjunct Professor Darryl O'Donnell) provided feedback on the draft supporting material (CEO Message, NHMRC Statement and Question-and-Answer resource).

Consumer consultation feedback was sought to ensure the materials were understandable by the community and addressed community concerns. The consumer representatives found the material was overall well delivered. It was suggested that more clarification and simple language could be used to assist understanding of certain technical terms. Editorial feedback was also received to improve the structure of the text. Where appropriate, NHMRC updated the draft supporting material to reflect the feedback received from the consumer representatives.

Contributors

The Committee had oversight over the development of the updated guidance during its 2022-2025 committee term. Committee membership for this term is outlined below.

Water Quality Advisory Committee (Term from 29 April 2022 to 31 December 2025)

- Professor Nicholas Ashbolt (Chair), Cooperative Research Centre for Solving Antimicrobial Resistance in Agribusiness, Food and Environments, University of South Australia
- Dr David Cunliffe, South Australian Department for Health and Wellbeing
- Mr Cameron Dalgleish, Tasmanian Department of Health
- Professor Cynthia Joll, Curtin Water Quality Research Centre, Curtin University
- Mr Peter Rogers, Water and Public Health Expert
- Ms Nicola Slavin, Northern Territory Department of Health
- Dr Bala Vigneswaran, Water and Public Health Expert
- Associate Professor Harriet Whiley, College of Science and Engineering, Flinders University
- Professor Frederic Leusch, School of Environment and Science, Griffith University (since 2023)
- Dr Nobheetha Jayasekara (Observer), Australian Industrial Chemicals Introduction Scheme (since 2023)
- Mr Laurence Wilson (Observer), National Indigenous Australians Agency
- Dr Sonia Colville (Observer), Department of Climate Change, Energy, Environment and Water (2022 – 2023)
- Mr Adam Lovell (Observer), Water Services Association of Australia (2022 – 2023)
- Ms Yulia Cuthbertson (Observer), Department of Climate Change, Energy, Environment and Water (since 2024).

Chemical Subgroup

Initial review of draft reports, drafting of updated guidance and subsequent revisions were undertaken by Committee members who were part of the Chemical Subgroup.

The following members of the Water Quality Advisory Committee formed the Chemical Subgroup:

- Professor Cynthia Joll (Subgroup Chair), Curtin Water Quality Research Centre, Curtin University
- Mr Cameron Dalgleish, Tasmanian Department of Health
- Professor Frederich Leusch (since 2023), School of Environment and Science, Griffith University.

NHMRC Project Team

Project work by NHMRC was undertaken by the Water Team in the Environmental Health Section of the Research Quality and Advice Branch.

Declarations of Interest

Appointees to committees of NHMRC are required to disclose their interests consistent with Section 42A of the Act, and instructions issued under sections 16A and 16B of the Public Governance, Performance and Accountability Rule 2014 (made under subsection 29(2) of the *Public Governance, Performance and Accountability Act 2013*). Prospective members were specifically asked to identify, to the best of their ability, interests including:

- financial interests: an interest must be declared when benefits or losses either in money or in-kind have occurred or may occur at a level that might reasonably be perceived to affect a person's judgement in relation to fair decisions about evidence and their participation in group decision-making
- other relationships: an interest must be declared when a strong position or prejudice or familial connection or other relationship held by a person could reasonably, or be perceived to, affect a person's judgement in relation to fair decisions about evidence and their participation in group decision-making including making an effort to arrive at a consensus
- affiliations to or associations with any organisations or activities that could reasonably be perceived to be an influence due to a competing interest, either for or against the issues being considered by the committee
- any other influences that might reasonably be considered likely to affect the expert judgement of the individual, or lead to the perception by others that the judgement of the individual is compromised.

Under the Public Governance, Performance and Accountability Act 2013, members have a responsibility to declare any interests to the whole committee, and members have a joint responsibility to decide on the management of any perceived or real conflict. No unmanageable conflicts were identified by the Committee or NHMRC.

Throughout the project, members were reminded of their obligation to consider any interest that may have arisen since the last meeting or with any particular agenda items. All disclosures and determinations about interests were recorded in the minutes of the Committee meetings. Members' relevant expertise and a summary of their disclosed interests were accessible on the NHMRC website throughout the duration of the project.

The relevant expertise of the Committee and a summary of their disclosed interests during the term of their membership is at **Appendix D**.

Project funding

This work was funded by NHMRC and the Department of Health and Aged Care.

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Appendix A – Evidence-to-Decision Tables

Evidence-to-decision table – Perfluorooctanoic acid (PFOA) (CAS 335-67-1)

The Evidence-to-Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Water Quality Advisory Committee.

Note that guideline options presented below are unrounded, pending advice from the Committee. However, the chosen guideline option presented in the fact sheet is rounded as per the rounding conventions described in Chapter 6 of the Australian Drinking Water Guidelines.

Criteria	OPTION 1: **Maintain the current health-based guideline value for PFOA of 560 ng/L** *(based on Lau et al. 2006)*	OPTIONS 2 to 10 **Lower health-based guideline value for PFOA in drinking water to a guideline value between 9.5 ng/L and 554 ng/L** *(based on either: Abbott et al. 2007; Butenhoff et al. 2012; DeWitt et al. 2008; Koskela et al. 2016; Li et al. 2017; Loveless et al. 2006; NTP 2023; Onishchenko et al. 2011; Song et al. 2018)* (see Attachments 1 and 2 below for details on guideline options for PFOA)
Draft recommendation	*Based on human health considerations, the concentration of PFOA in drinking water should not exceed 560 ng/L (0.56 µg/L).*	*Based on human health considerations, the concentration of PFOA in drinking water should not exceed [value of 9.5 ng/L to 554 ng/L] [0.0095 to 0.55 µg/L].*
Health evidence profile	A review of existing guidance and guidelines found that the current Australian guideline value	A review of existing guidance and guidelines (SLR 2024a, b, c) identified several potential guideline values ranging from 9.5 to 554 ng/L that were found suitable to

	of 560 ng/L in drinking water is still considered suitable (SLR 2024a, b). The current NHMRC health-based guideline value of 560 ng/L was published in August 2018. It is based on a Tolerable Daily Intake (TDI) of 160 ng/kg bodyweight/day (established by FSANZ (2017)) on the basis of a NOAEL for foetal toxicity in a developmental and reproductive study in mice (Lau et al. 2006). The Lau et al. (2006) study underpinning the current guideline value was assessed as high confidence (SLR 2024a, b). An assessment of the study methodology found that it had been conducted according to OECD Test Guidelines that examined a number of standard endpoints with appropriate sample sizes of treated and control groups. A recent review undertaken by an international panel of scientists (Burgoon et al. 2023) also found Lau et al. (2006) to be one of five studies of sufficient quality to derive a guidance value. While the current NHMRC health-based guideline value for PFOA is one of the highest guideline values for PFOA published, it is considered to be based on a high-quality study (Lau et al. 2006). The point of departure used by NHMRC from Lau	potentially adopt/adapt for the Australian context. These candidate guideline options are based on a range of critical health effects in rats and mice that include skeletal alterations, liver toxicity, developmental delays, increased relative liver weight, decreased growth rate and pup survival and non-neoplastic hepatocellular necrosis. The lowest proposed guideline option (9.5 ng/L) is a similar order of magnitude to the drinking water guideline value for PFOA set by the US EPA (2024b) of 4 ng/L, although it is noted that the US EPA value is not health-based but based on a practical quantification limit (ability to measure PFOA accurately). The NHMRC review findings suggested that some of the underpinning studies used to derive the potential recent international guideline values are not of high enough quality to warrant revision of the current Australian guideline value for PFOA (SLR 2024a, b, c). The review found that there was low to very low confidence in some of the key studies used in the included potential guideline candidates based on various issues identified in the respective study methodologies. These included limitations such as uncertainty regarding the clinical relevance of the observed health effects to humans, small sample size and a lack of dose response. However, the review found that some of the candidate studies used by US EPA (2024b) and Burgoon et al. (2023) provide appropriate new information to consider revision of the current Australian health-based guideline value for PFOA (SLR 2024c). The additional review (SLR 2024c) found that there was high to medium confidence in several key studies that examined carcinogenicity and immune effects (Butenhoff et al. 2012; Dewitt et al. 2008; NTP 2023). While Butenhoff et al. (2012) and Dewitt et al. (2008) were found to be of medium confidence (SLR 2024c), the NTP (2023) 2-year carcinogenicity and toxicity study referenced by US EPA (2024b) that observed non-neoplastic hepatic necrosis and neoplastic pancreatic effects was considered to have the highest confidence as it is a high-quality study, was conducted appropriately and

	et al. (2006) is much higher than those used by other agencies reviewed (SLR 2024a, b, c) who have based their health advice on different critical health endpoints (e.g. non-threshold cancer effects, immunomodulation effects).	assessed effects across all developmental life stages (SLR 2024c). The International Agency for Cancer Research (IARC), who have found that PFOA is a Group 1 carcinogen, also cited NTP (2023) as sufficient evidence of cancer in animals in their evaluation summary (Zahm et al. 2024), noting that full details of the IARC evaluation were not available at the time of the review. Although SLR (2024c) noted that the acinar pancreatic neoplastic lesions in rats observed in NTP (2023) are unlikely to be relevant to humans due to their probable formation through the rat-specific peroxisome proliferator-activated receptor alpha (PPARα) pathway (SLR 2024c), it was also noted that the formation of the observed pancreatic effects may occur through modes of action other than the PPARα pathway (currently demonstrated in vitro but not in vivo) and so human relevance could not be discounted (SLR 2024c). In addition, while rats are likely more sensitive to the observed liver effects (hepatocellular necrosis) in NTP (2023) than humans, it was considered there was insufficient information to rule out human relevance of this adverse effect at this time (SLR 2024c). Please refer to **Attachments 1 and 2** (below) for the health evidence profile for these guideline options.
Exposure profile	PFOA has been detected at concentrations ranging from below detection **to 9.7 ng/L** in Australian raw and/or reticulated drinking water supplies (Hunter Water 2024; Power and Water n,d.; QAEHS 2018a, 2018b; Sydney Water 2024; WCWA 2023), including in a study of 33 Australian drinking water samples (Thompson *et al.* 2011). This maximum concentration slightly exceeds the lowest candidate guideline option of 9.5 ng/L but will be below the other candidate guideline options under consideration. Due to the uncertainty factors and small relative source contribution (RSC) incorporated into the derivation of the candidate guideline options and the existing Australian health-based guideline value, PFOA is unlikely to present a human health risk from most Australian distributed drinking waters that are not impacted by site contamination. Maximum concentrations of PFOA in contaminated residential and private bores has been detected between 20 to 10,500 ng/L (AECOM 2017a, 2017b; BSC 2021; GHD 2018).	

	The main factor to consider for exposure to PFAS in drinking water is whether drinking water infrastructure is located in the vicinity of potentially contaminating activities. However, it is noted that low concentrations of PFAS have been detected in water supplies not impacted by contaminated sites. There are many sites of PFAS contamination in Australia, and if water from these contaminated sites is used as a local source of drinking water (e.g. backyard bore in rural location where distributed water is not available) exceedances of PFAS guideline levels may occur (SLR 2024a, b).	
Health benefits vs harms	According to the SLR (2024a, b, c) review, the current candidate guideline value option is considered suitable to maintain for guideline derivation as it is underpinned by a high confidence study. However, there may be concerns as the current guideline value is higher than guideline values in other jurisdictions (e.g. USA and Europe) (see values and preferences). There is also more recently published, high quality evidence that is appropriate to consider for revision of the current Australian health-based guideline value for PFOA.	Lower guideline options are more conservative options compared to higher guideline values. However, the choice of guideline option should balance the need for conservatism against the highest quality evidence and whether the health endpoints under consideration (if using animal studies) are relevant and critical to humans. Lowering the guideline value may result in an increase of exceedances detected in communities, and there may be potential harm for people living in PFAS affected communities (e.g. higher psychological distress), if concentrations are nearing these lower guideline values in their areas. See values and preferences.
Values and preferences (consumers, communities)	Human exposure to PFAS is an ongoing concern to consumers and communities, particularly to those who live in communities affected by PFAS. PFAS contamination can have a range of consequences for those affected including impacts on property values, produce, income, reputation and risks to health. Findings from the PFAS Health study showed that people living in PFAS affected communities, irrespective of PFAS blood concentrations, are more likely than those who live in comparison areas to experience psychological distress. It is reasonable to assume that consumers and communities, particularly those experiencing the impacts of contamination, would expect that: • supplied drinking water is safe to drink and that PFAS would not be present in drinking water at levels that might cause harm to public health	

	• new/emerging risks to public health from drinking water are considered by NHMRC and appropriate action is taken depending on the risks to public health • that the selected guideline option will be protective of public health. It is likely that consumers and communities (particularly those affected by PFAS contamination) will continue to be risk-averse to the effects of exposure to PFOA. Some groups will expect Australia to follow the lead of international agencies that have adopted very conservative guideline values or used different critical health endpoints. While the findings of the NHMRC review should reassure the public that the health evidence has been considered and why a particular guideline value was chosen, clear and consistent public health messaging and plain language risk communication will still be required to help explain the differences between international jurisdictions, the uncertainty in the evidence and the NHMRC review process.	
Acceptability (other key stakeholders)	The recent public and media interest in the potential carcinogenicity of PFOA (based on overseas advice) will mean that this guideline option might not provide enough certainty to stakeholders such as health regulators and water providers about the level of risk from PFOA at concentrations found in Australian distributed drinking waters. Although the health evidence for recent changes in international guidance/guideline values will have been reviewed and critically assessed by NHMRC using best practice review methods for the Australian context, there might be some concerns that NHMRC is not aligning with other international bodies who have decreased their guideline values for PFOA based on other endpoints and more	The proposed lowered guideline options for PFOA will be more conservative options. The acceptability of these guideline options to stakeholders who implement the Guidelines will be affected by the certainty of the underpinning evidence. Some of the lower guideline options, while inherently more conservative, were found to be underpinned by key studies that were assessed as having low to very low confidence in their study quality. Stakeholders who have higher resource impacts if these guideline options are implemented may find them less acceptable to implement if the justification for a change in practice is based on low quality evidence that has been found to have low certainty. Guideline options that are underpinned by high confidence studies would be more acceptable to stakeholders. Factors that might impact acceptability of lower guideline options for stakeholders include: • increased regulatory burden for health regulators and/or drinking water authorities as more exceedances in drinking water supplies might be detected as a result of lowering the guideline value

	recently published studies if this guideline option is adopted. However, the review demonstrates that this guideline option is based on a study with higher confidence (Lau *et al.* 2006) compared to most of the other proposed guideline options identified in the review (SLR 2024a, b, c). However, it is noted that there is also a high certainty guideline option based on more recently published evidence with critical health effects (neoplastic pancreatic tumours, non-neoplastic liver effects) observed at a lower concentration than current NHMRC advice (NTP 2023; SLR 2024c).	• monitoring requirements for water providers may increase, especially in contaminated areas • lack of alignment with other international agencies who have established lower health-based guideline values or used different health endpoints.
Feasibility	This guideline option is feasible as no changes to current practice are required.	These lower guideline options are technically feasible. According to the SLR (2024a, b) review, the guideline options would be achievable with existing treatment technologies and readily measurable with current commercial analytical techniques. Although existing conventional water treatment technologies do not appear to be particularly effective at removing PFOA from water, the guideline options are/would be achievable if source waters with concentrations below the guideline value are utilised. However, the guideline options may not be achievable for local drinking water supplies in contaminated areas without addition of a PFAS-removal treatment step or use of an alternative water supply.

Health equity impacts	While some of the guideline values under consideration are more conservative than others, all of the guideline options are considered protective of public health for the general population, including groups that may be more sensitive (e.g. infants, children and pregnant women). This also includes populations who may be more exposed to PFOA based on their proximity to contaminated sites.	
Resource impacts	None. There would be no change in practice if the current guideline value is retained.	All of the guideline options that result in lowering the current guideline value may have resource impacts on the water sector. Water providers may be unwilling to cover increased operational costs if there is lower certainty in the evidence for lower guideline values. Lowering the guideline value may result in an increase of exceedances detected in communities. Through various reporting obligations, water utilities may need to report these exceedances publicly. Additional monitoring and treatment programs (including infrastructure) may be required to treat drinking water supplies to meet lowered guideline values. The lower the guideline value, the more treatment will be required. Resulting costs for additional treatment of drinking water supplies or investment in appropriate treatment technologies may be borne by local water providers. In some cases, a new water source may need to be developed to meet guideline values. This may have flow on costs to consumers and communities.
Decision	**Decisions regarding the following guideline options by the Water Quality Advisory Committee are outlined below:**	
Option 1	While based on a high-quality study, a guideline value of 560 ng/L was not selected as it was no longer considered appropriate given that high quality, recently published evidence was available to set a new, lower guideline value for PFOA in drinking water.	
Options 2-6, 8-10	These guideline values were not selected as they were not considered the best available evidence from which to derive a guideline value. The review considered these studies to be of very low, low or medium confidence based on various study limitations, including uncertainty	

	surrounding the clinical relevance of the observed health effects in humans versus animals, small sample sizes and a lack of clear dose-response relationships or serum PFOA data (SLR 2024a, b, c).
Option 7a	The non-neoplastic critical effect of hepatocellular necrosis was not chosen as the point of departure to derive a health-based guideline value for PFOA of 402 ng/L (based on NTP 2023) as the neoplastic effects in option 7b were considered to be the more critical effect resulting in a lower (more conservative) guideline value.
Option 7b	Members noted that although there are uncertainties about the clinical relevance of neoplastic pancreatic tumours in rats to humans, these findings could not be completely dismissed in light of in vitro studies that may support a relevant mode of action in humans. Given the classification of PFOA as a Group 1 carcinogen by IARC and the rating by US EPA (2024b) that the NTP (2023) findings were from a high confidence study, Members agreed the neoplastic pancreatic effects observed in the high-quality NTP (2023) study were an appropriately conservative point of departure to derive a health-based guideline value for PFOA of 200 ng/L (rounded from 227 ng/L to 1 significant figure).

*can include other factors/criteria such as those listed in validated tools such as GRADE-DECIDE and WHO-INTEGRATE as required.

Attachment 1: PFOA Evidence Profile (extracted from SLR 2024a, b) – to be read in conjunction with Evidence-to-Decision Table

	Option 1	Option 2	Option 3	Option 4	Option 5
Criteria	**Maintain** the current health-based guideline value for PFOA of **560 ng/L**	**Lower the** health-based guideline value for PFOA in drinking water to **70 ng/L**	**Lower** the health-based guideline value for PFOA in drinking water to **45 ng/L**	**Lower** the health-based guideline value for PFOA in drinking water to **16 ng/L**	**Lower** the health-based guideline value for PFOA in drinking water to **9.5 ng/L**
Health evidence profile					
Source of Drinking Water Guideline (DWG)	NHMRC and NRMMC 2011, FSANZ 2017	NJDEP 2019a New Jersey Department of Environmental Protection	MPART 2019 Michigan's PFAS Action Response Team	OEHHA 2019 California Environmental Protection Agency	ATSDR 2021a US Agency for Toxic Substances and Disease Registry
Health-based guidance value (HBGV)	160 ng/kg/day	20 ng/kg/day	12.9 ng/kg/day	4.5 ng/kg/day	2.7 ng/kg/day

Resulting adaption to a Health-based Drinking Water Guideline (DWG)	560 ng/L	70 ng/L	45 ng/L	16 ng/L	9.5 ng/L
Critical study	**Lau et al. 2006** (developmental toxicity study in pregnant mice)	**Loveless et al. 2006** (rats and mice)	**Onishchenko et al. 2011, Koskela et al. 2016** (pregnant mice)	**Li et al. 2017** (mice)	**Koskela et al. 2016** (pregnant mice)
Proportion of technical/ administrative criteria for potential adoption/ adaption into Guidelines[3]	**High** proportion	**High** proportion	**Low** proportion (should have); **High** proportion (must have and may have)	**Low** proportion	**High** proportion
Critical Effect	Decreased pre-weaning growth rate in pups.	Increased relative liver weight in male mice.	Developmental delays (decreased number of inactive periods, altered novelty induced activity and skeletal alteration such as bone morphology and bone cell differentiation in the femurs and tibias) of mice.	Liver toxicity (↑ oxidative DNA damage, changes in mitochondrial membrane potential, and ↑ biomarkers of apoptosis in liver of female mice).	Skeletal alterations (i.e. altered femur and tibial bone morphology, ↓ tibial mineral density) in adult mouse offspring.
Confidence in candidate guideline value	**High** Study appears to have been conducted using a protocol similar to OECD TG 414 (prenatal developmental toxicity study) and examined a large number of standard endpoints[4] in a sufficiently large number of	**Low** There is uncertainty with respect to the human relevance of the liver effects observed in this study due to the dearth of mode of action information for these effects and suggested human	**Very low** Koskela et al. (2016) study: small animal numbers (n=6 in treated group), only a single treatment group (one PFOA dose level), inadequate reporting of dietary PFOA levels, lack of measured serum PFOA levels and	**Low** Potential that the effects on apoptosis observed in male and female mice may not be relevant to humans. It is arguable whether the effects observed at the lowest dose in this study (0.05 mg/kg/day) in	**Very low** Refer to limitations for Koskela et al. (2016) in Option 3. Despite the limitations, the outcome does appear to be compelling and, if relevant to humans, could potentially

[3] Refer to Figure 9-1 Evidence Evaluation Report (p70) for more details (SLR 2024a, b). Jurisdiction guidance/guideline met a high (i.e. ~>60%) proportion of 'must-have' and 'should-have' criteria; lower proportions of criteria indicate these guidance documents potentially do not conform with modern methods of undertaking systematic reviews. Full details of the assessment of the jurisdiction guidance/guideline is at Appendix D of the Technical Report (SLR 2024a, b).

[4] Endocrine disruptor relevant parameters (i.e. anogenital distance in foetuses and thyroid hormones in dams) were only added to the OECD TG in 2018. These endpoints were not included in the Lau et al. (2006) study, since the OECD TG update superseded the conduct and publication of the Lau et al. (2006) study.

	treatment groups and treated animals. The Lau et al. (2006) study was one of five studies used by an international collaboration of scientists (**Burgoon et al. 2023**) to estimate a PFOA guidance value approximately two times lower than the FSANZ (2017) value. More information on this paper, including the differences in the derivation of guidance values using the Lau et al. (2006) study is on p83 of the Evidence Evaluation Report (SLR 2024a, b).	refractoriness for some of these effects. This aligns with the conclusions in the FSANZ (2017) review.	uncertainty with respect to the clinical relevance of the findings. The use of only one PFOA dose level does not allow for the establishment of dose-response relationships. This study limitation is mitigated by the extensive intermediate-duration oral exposure database, which allows for an overall assessment of dose-response. Onishchenko et al. (2011) study: not conducted in accordance with standardised testing guidelines; apparent small absolute differences in effects observed between the treated and control groups.	female mice can be considered adverse. FSANZ (2017) indicates that humans may be refractory to the liver effects observed in rodents as a result of PFOA exposure.	increase the risk of bone fractures later in life (SLR 2024a).

Attachment 2: PFOA Evidence Profile (extracted from SLR 2024c) – to be read in conjunction with Evidence-to-Decision Table

	Option 6	**Option 7**	**Option 8**	**Option 9**	**Option 10**
Criteria	**Lower the** health-based guideline value for PFOA in drinking water to **554 ng/L**	**Lower the** health-based guideline value for PFOA in drinking water to **227 or 402 ng/L**	**Lower** the health-based guideline value for PFOA in drinking water to **111 ng/L**	**Lower** the health-based guideline value for PFOA in drinking water to **75 or 172 ng/L**	**Lower** the health-based guideline value for PFOA in drinking water to **63 ng/L**
Health evidence profile					
Source of Drinking Water Guideline (DWG)	US EPA 2024b	US EPA 2024b	Burgoon et al. 2023	US EPA 2024b	US EPA 2024b
Health-based guidance value (HBGV)	158 ng/kg/day	a) 115 ng/kg/day	32 ng/kg/day	a) 21 ng/kg/day	18 ng/kg/day

		b) 65 ng/kg/day[5]		A. 49 ng/kg/day[6]	
Resulting adaption to a Health-based Drinking Water Guideline (DWG)	554 ng/L	a) 402 ng/L b) 227 ng/L[5]	111 ng/L	a) 75 ng/L b) 172 ng/L[6]	63 ng/L
Critical study	**Butenhoff et al. 2012** (2-year combined chronic toxicity and carcinogenicity rat study)	**NTP 2023** (2-year carcinogenicity and toxicity study in rats)	**Abbott et al. 2007** (developmental toxicity study in pregnant mice)	**Song et al. 2018** (mice study)	**DeWitt et al. 2008** (mice study)
Proportion of technical/ administrative criteria for potential adoption/ adaption into Guidelines[7]	**High** proportion	**High** proportion	**High** proportion	**High** proportion	**High** proportion
Critical Effect	Microscopic anatomic pathological evidence of hepatotoxicity & Leydig cell tumours.	a) Non-neoplastic: Hepatocellular necrosis b) Neoplastic: Pancreatic acinar adenomas & adenocarcinomas[5]	Decreased mice pup survival.	Decreased mice pup survival.	Reduction in IgM response to sheep red blood cells (SRBC) (7% cf. controls at LOAEL).
Confidence in candidate guideline value	**Medium** Overall, the resulting adapted guideline value is considered to be of medium confidence, as the underpinning study was well-conducted but lacked serum PFOA measurements reported in	**High** The NTP 2023 study is a high-quality study and has been conducted appropriately. The US EPA (2024b) also considered the study to be of high confidence.	**Low** The reliability of the Abbott et al. (2007) study for human health risk assessment purposes is considered to be low due to the high background rate of litter loss	**Low** Considered to be of low confidence as the Song et al. (2018) study focused on specific endpoints of interest in mice, therefore it did not follow standardised protocols for	**Medium** Study appears to have been conducted appropriately and incorporated a recovery phase; it evaluated a number of parameters including immune system markers. There was a

[5] US EPA (2024b) used the NTP (2023) study to derive a candidate guidance value based on non-neoplastic effects (i.e. liver cell necrosis), however the agency also present BMD modelling for the neoplastic effects (pancreatic acinar adenomas and adenocarcinomas). The $BMDL_{10RD}$ for neoplastic effects has also been presented in this table and used to derive an additional candidate guideline value using the same uncertainty factors used by US EPA (2024b) for the non-neoplastic effects. However, it is recognised that the acinar pancreatic neoplastic lesions are unlikely to be relevant to humans based on currently available information, although they can't be completely dismissed at this time. Although there is uncertainty with respect to the dose at which non-neoplastic hepatic effects may occur in humans and it is recognised by SLR (2024c) that rats are likely more sensitive to this effect that humans, SLR (2024c) considers there is insufficient information to rule out human relevancy of this effect based on currently available information.

[6] The different values provided (a and b) represent the different clearance values and points of departure (POD) used by the US EPA 2024b. The difference for this result is not clear from SLR's reading of the agency documentation. For this reason, both POD_{HED} values are shown in this table. Refer to Section 6.2.9 in Addendum Report (SLR 2024c) for more information.

7 Jurisdiction guidance/guideline met a high (i.e. ~>60%) proportion of 'must-have' and 'should-have' criteria; lower proportions of criteria indicate these guidance documents potentially do not conform with modern methods of undertaking systematic reviews. Full details of the assessment of the Burgoon et al. 2023 and US EPA 2024b guidance is in Appendix B of the Addendum Report (SLR 2024c).

	the study (it is noted US EPA 2024b provided serum data for the study; it is unclear whether this is modelled or measured data).	The candidate guideline value resulting from adaption of the US EPA (2024b) candidate guidance value (and POD for non-neoplastic effects) is considered to be of high confidence. The neoplastic effects observed (acinar pancreatic neoplastic lesions) are unlikely to be relevant to humans based on currently available information, however human relevance cannot be entirely discounted (SLR 2024c).	in the controls, the high level of litter loss at doses greater than 1 mg/kg bw/day, the lack of clear reporting on maternal mortality, the variable statistical power across the different dose groups, the limited descriptions of the study design and the lack of historical control data for the strain of mouse used.	developmental toxicity experiments screening for a larger suite of endpoints. The reported serum PFOA concentration in the paper is also considered unreliable. Although no statistical difference was reported between litter sizes at PND0, statistical analysis of the various endpoints did not include the litter in the model to guard against an inflated Type I error rate.	clear dose response observed for reduction in IgM response to SRBC in female mice. Thus, the candidate guideline value resulting from adaptation of the US EPA (2024b) candidate guidance value (incorporating the use of a NOAEL instead of a $BMDL_{1SD}$ value) is considered to be of medium confidence. US EPA (2024b) also considered the study to be of medium confidence.

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Evidence-to-Decision table – Perfluorooctane sulfonic acid (PFOS) (CAS 1763-23-1)

The Evidence-to-Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Water Quality Advisory Committee.

Note that guideline options presented below are unrounded, pending advice by the Committee. However, the chosen guideline option presented in the fact sheet is rounded as per the rounding conventions described in Chapter 6 of the *Australian Drinking Water Guidelines*.

Criteria	OPTION 1a: Maintain the current health-based guideline value for PFOS + PFHxS of 70 ng/L *(based on Luebker et al. 2005)*	OPTION 1b: Establish a health-based guideline value for PFOS of 70 ng/L ***(to consider if establishing separate guideline value for PFHxS)*** *(based on Luebker et al. 2005)*	OPTION 2: Establish a separate health-based guideline value for PFOS of 27 ng/L *(based on Zhong et al. 2016)*	OPTION 3: Establish a separate health-based guideline value for PFOS of 95 ng/L *(based on Zhong et al. 2016)*	OPTION 4: Establish a separate health-based guideline value for PFOS of 3.4 ng/L *(based on NTP 2022)*	OPTION 5: - Establish a separate health-based guideline value for PFOS of 77 ng/L *(based on NTP 2022)*
Draft recommendation	*Based on human health considerations, the sum of the concentrations of PFOS and PFHxS in drinking water should*	*Based on human health considerations, the concentration of PFOS in drinking water should not exceed 70 ng/L (0.07 µg/L).*	*Based on human health considerations, the concentration of PFOS in drinking water should not*	*Based on human health considerations, the concentration of PFOS in drinking water should not*	*Based on human health considerations, the concentration of PFOS in drinking water should not*	*Based on human health considerations, the concentration of PFOS in drinking water should not exceed 77 ng/L (0.077 µg/L).*

	not exceed 70 ng/L (0.07 µg/L).		*exceed 27 ng/L (0.027 µg/L).*	*exceed 95 ng/L (0.095 µg/L).*	*exceed 3.4 ng/L (0.0034 µg/L).*	
Health evidence profile	A review of existing guidance and guidelines (SLR 2024a, b) found that the current Australian guidance value for PFOS of 20 ng/kg/day and guideline value of 70 ng/L are still considered suitable for guideline derivation. It is also considered reasonable to retain the existing guideline value of 70 ng/L as the sum of PFOS and PFHxS; however, it is noted that the retention of the current health-based guideline value for the sum of PFOS and PFHxS should be considered in the context of the available health evidence for PFHxS. The current NHMRC health-based guideline value for the sum of PFOS and PFHxS (70 ng/L) was published in August 2018. It is based on a tolerable daily intake (TDI) of 20 ng/kg bodyweight/day (established by FSANZ (2017)) on the basis of decreased parental and offspring body weight gains in a multigenerational reproductive toxicity study in rats orally exposed to PFOS (Luebker *et al.* 2005). At that time, FSANZ concluded that there was insufficient toxicological and epidemiological evidence to justify establishing		A review (SLR 2024a, b) identified ten existing guidance/guidelines for PFOS that were suitable for potential adoption/ adaption in Australia. Of these, two underpinning studies had not been considered by FSANZ in their 2017 evaluation. These were found unsuitable to derive a tolerable daily intake. These were EFSA (2020) and the US EPA (2022c, e) which used two different studies to underpin their guidance derivations: Abraham *et al.* (2020) (used by EFSA 2020) and Budtz-Jørgensen and Grandjean (2018) (used by US EPA 2022c, e). Based on a brief critical evaluation of these two studies and consistent with the conclusions made by FSANZ (2021), SLR (2024a, b) concluded that a causal relationship between increased PFAS serum levels and impaired vaccine response cannot be established with reasonable confidence from the available human epidemiological information. The evidence for an association between increasing PFAS serum levels and impaired vaccine response was found to be insufficient for the endpoint to be used for derivation of a PFOS health-based guideline value. Although the reduced antibody response following vaccination has been considered by several jurisdictions as the most robust end point based on epidemiological data, it is unclear whether this correlation results in increased rates of infection and hence the clinical implications are uncertain. An additional review (SLR 2024c) of the key studies considered in reviews by US EPA (2024c) and Burgoon *et al.* (2023) identified several potential guideline values for PFOS ranging from 3.4 ng/L to 95 ng/L that were considered as being suitable to adopt/adapt for the Australian context. These candidate guideline options are based on critical health effects of decreased plaque forming cell responses of splenic cells in four-week-old male mice and bone marrow effects (i.e. extramedullary haematopoiesis and bone marrow hypocellularity) in rats. The additional review findings suggest two candidate studies considered by US EPA		

	a TDI for PFHxS. However, it was decided as a precaution and for the purposes of site investigations, the PFOS TDI should apply to PFHxS. In practice, this means that the level of PFHxS exposure should be added to the level of PFOS exposure; and this combined level be compared to the TDI for PFOS. In the absence of a TDI for PFHxS, FSANZ concluded at the time that it was reasonable to consider that the TDI for PFOS is likely to be conservative and protective of human health as an interim measure. The Luebker *et al.* (2005) study was assessed as high confidence as it was found to be a comprehensive, high-quality study that had been conducted appropriately and investigated a large number of endpoints (SLR 2024a, b, c). While the current NHMRC health-based guideline value for PFOS is one of the highest guideline values for PFOS published, it is considered to be based on a high-quality study (Luebker *et al.* 2005). The point of departure used by NHMRC from Luebker *et al.* (2005) is much higher than those used by other agencies reviewed (SLR 2024a, b, c) who have based their health advice on different critical health	(2024c), Zhong *et al.* (2016) and NTP (2022), provide appropriate new information to consider revision of the current Australian health-based guideline value for PFOS. The Zhong *et al.* (2016) study was assessed as medium confidence as it appears to have been conducted appropriately, albeit it was of a pilot study nature; it evaluated a large number of immune system markers, as well as hormone levels and clinical parameters. There was a clear dose response for parameters of the immune system to be affected in male mice (SLR 2024c). US EPA (2024c) also considered the Zhong *et al.* (2016) study to be of medium confidence. The NTP (2022) study was assessed as high confidence as it is a comprehensive, high-quality study, has been conducted appropriately and investigated a large number of endpoints (SLR 2024c). US EPA (2024c) also considered the study to be of high confidence. Several different points of departure from the NTP (2022) study were also proposed based on bone marrow effects and whether a serum NOAEL or modelled benchmark dose level were applied (SLR 2024c). There was higher confidence by SLR (2024c) in the application of a point of departure derived from a NOAEL identified from measured serum levels in experimental animals (resulting in a guideline value off 77 ng/L), versus a modelled $BMDL_{10}$ used by the US EPA which did not reconcile with experimental serum data and resulted in a guideline value of 3.4 ng/L. SLR (2024c) noted that there was a large (29-fold) difference between the modelled BMDL used by US EPA (2024c) and the measured serum no observed adverse effect level (NOAEL) in female rats (SLR 2024c). There was also a 5-fold difference between the modelled BMDL used by the US EPA (2024c) and the NOAEL in male rats (SLR 2024c). Please refer to **Attachment 1** (below) for the health evidence profile for each guideline option.

	endpoints (e.g. non-threshold cancer effects, immune system, spleen effects).	
Exposure profile	PFOS has been detected at concentrations ranging from below detection to 16.4 ng/L in Australian raw and/or reticulated drinking water supplies (Hunter Water 2024; QAEHS 2018a, 2018b; Sydney Water 2024), including in a study of 33 Australian drinking water samples (Thompson *et al.* 2011). PFOS+PFHxS concentration was at 90% of the Australian health-based guideline value (i.e. ~60 ng/L) in one bore in a drinking water borefield supplying Esperance, Western Australia (SLR 2024a, b). Once this apparent PFOS/PFHxS contamination was identified, this bore was no longer used. SLR (2024a, b) noted that PFOS is unlikely to present a human health risk from most major Australian distributed drinking waters that are not impacted by site contamination. However, it is noted that low concentrations of PFAS have been detected in water supplies not obviously impacted by contaminated sites. This indicates that compliance with the lower candidate health-based guideline value for PFOS (i.e. 3.4 ng/L) may present an issue in certain circumstances. Nevertheless, based on publicly available monitoring information and due to the large uncertainty factors and small relative source contribution of 10% incorporated into the derivation of the candidate health-based guideline value, PFOS is unlikely to present a human health risk from distributed drinking water from most water supplies. In addition, maximum concentrations of PFOS in contaminated residential and private bores has been detected between 80 to 136,000 ng/L (AECOM 2017, 2017b; Bräunig *et al.* 2017; BSC 2021; GHD 2018). The main factor to consider for exposure to PFAS in drinking water is whether drinking water infrastructure is located in the vicinity of potentially contaminating activities. There are many sites of PFAS contamination in Australia, and if water from these contaminated sites is used as a local source of drinking water (e.g. backyard bore in rural location where distributed water is not available), exceedances of PFAS guideline levels may occur (SLR 2024a, b).	
Health benefits vs harms	According to the SLR (2024a, b, c) review, these guideline options are still considered suitable for guideline value derivation as they are underpinned by a high confidence study.	Lower guideline options are more conservative options compared to higher guideline values. However, the choice of guideline option should balance the need for conservatism against the highest quality evidence and whether the health endpoints under consideration (if using animal studies) are most relevant and critical to humans.

	However, it is noted that if a separate guideline value for PFHxS is established (see PFHxS Evidence to Decision table), and the health-based guideline value for PFOS remains at 70 ng/L, it would potentially raise the allowable amount of PFOS and PFHxS in drinking water to an overall higher concentration of 104 ng/L (i.e. if a guideline value of 34 ng/L for PFHxS is established).	Lowering the guideline value may result in an increase of exceedances detected in communities, and there may be potential harm for people living in PFAS affected communities (e.g. higher psychological distress), if concentrations are nearing or over the lower guideline values in their areas. See values and preferences.
Values and preferences (consumers, communities)	Human exposure to PFAS is an ongoing concern to consumers and communities, particularly to those who live in communities affected by PFAS. PFAS contamination can have a range of consequences for those affected including impacts on property values, produce, income, reputation and risks to health. Findings from the PFAS Health study showed that people living in PFAS affected communities, irrespective of PFAS blood concentrations, are more likely than those who live in comparison areas to experience psychological distress. It is reasonable to assume that consumers and communities, particularly those experiencing the impacts of contamination, would expect that: • supplied drinking water is safe to drink and that PFAS would not be present in drinking water at levels that might cause harm to public health • new/emerging risks to public health from drinking water are considered by NHMRC and appropriate action is taken depending on the risks to public health • that the selected guideline option will be protective of public health. It is likely that consumers and communities (particularly those affected by PFAS contamination) will continue to be risk-averse to the effects of exposure to PFOS. While the findings of the NHMRC review should reassure the public that the health evidence has been considered and why a particular guideline value was chosen, there is likely to be ongoing concern from some groups if Australian advice doesn't completely align with other international agencies that have adopted more conservative guideline values or used different critical health endpoints.	

	Clear and consistent public health messaging and risk communication, including explanations about the differences between international jurisdictions, guideline value derivations and the NHMRC review process, could help explain these issues to consumers and reassure them about Australian processes.	
Acceptability (other key stakeholders)	The recent public and media interest in the potential health effects of PFOS will mean that this guideline option (representing no change in the level of PFOS) might not provide enough certainty to stakeholders such as health regulators and water providers about the level of risk from PFOS at concentrations found in Australian distributed drinking waters. Although the health evidence for recent changes in international guidance/guideline values will have been reviewed and critically assessed by NHMRC using best practice review methods for the Australian context, there might be some concerns that NHMRC is not aligning with other international bodies who have decreased their guideline values for PFOS based on other endpoints and more recently published studies if this guideline option is adopted. However, the review demonstrates that this guideline option is based on a study with higher confidence (Luebker *et al.* 2005) compared to most of the other proposed guideline options identified in the review (SLR 2024a, b, c). However, it is	The acceptability of these guideline options to stakeholders who implement the Guidelines will be affected by the certainty of the underpinning evidence. Some of the proposed guideline options were found to be underpinned by key studies that were assessed as having medium confidence in their study quality, or low confidence in the methods used to derive a point of departure. Stakeholders who have higher resource impacts if these guideline options are implemented may find them less acceptable to implement if the justification for a change in practice is based on low quality evidence that has been found to have low certainty. Guideline options that are underpinned by high confidence studies would be more acceptable to stakeholders. Factors that might impact acceptability of lower guideline options for stakeholders include: • increased regulatory burden for health regulators and/or drinking water authorities as more exceedances in drinking water supplies might be detected as a result of lowering the guideline value • monitoring requirements for water providers may increase, especially in contaminated areas • lack of alignment with other international agencies who have established lower health-based guideline values or used different health endpoints.

	noted that there is also a high certainty guideline option based on more recently published evidence based on bone marrow effects in rats (i.e. extramedullary haematopoiesis and bone marrow hypocellularity) (NTP 2022; SLR 2024c). While establishing a separate guideline value for PFOS is considered appropriate, stakeholders such as consumers and health regulators may find this option less acceptable, as it would potentially raise the overall concentration of PFOS and PFHxS allowable in drinking water from 70 to 104 ng/L based on the sum of their separate health-based guideline values (i.e. 70 ng/L PFOS and 34 ng/L PFHxS = 104 ng/L PFOS+PFHxS).	
Feasibility	These guideline options are feasible as no changes to current practice are required.	These guideline options, including lower guideline options as used by some international jurisdictions, are technically feasible. Although existing conventional water treatment technologies do not appear to be particularly effective at removing PFOS from water, lower guideline options would be achievable if source waters with concentrations below the guideline value are utilised.
Health equity impacts	While some of the guideline values under consideration are more conservative than others, the proposed guideline options are considered protective of public health for the general population, including groups that may be more sensitive (e.g. infants, children and pregnant women). This also includes populations who may be more exposed to PFOS based on their proximity to contaminated sites.	

Resource impacts	None. There would be no change in practice if the current guideline value is retained. Setting a separate health-based guideline value for PFOS is unlikely to have resource impacts on the water sector as PFOS and PFHxS are currently measured separately (then reported together).	Guideline options that result in lowering the current guideline value may have resource impacts on the water sector. Water providers may be unwilling to cover increased operational costs if there is lower certainty in the evidence for lower guideline values. Lowering the guideline value may result in an increase of exceedances detected in communities. Through various reporting obligations water utilities may need to report these exceedances publicly. Additional monitoring and treatment programs (including infrastructure) may be required to treat drinking water supplies to meet lowered guideline values. The lower the guideline value, the more treatment will be required. Resulting costs for additional treatment of drinking water supplies or investment in appropriate treatment technologies may be borne by local water providers. In some cases, a new water source may need to be developed to meet guideline values. This may have flow on costs to consumers and communities.
Decision	Decisions regarding the following guideline options by the Water Quality Advisory Committee are outlined below:	
Option 1a	A sum of PFOS and PFHxS of 70 ng/L was not selected as it was no longer considered appropriate given that sufficient evidence was available to set separate guideline values for PFOS and PFHxS.	
Option 1b	The guideline option of 70 ng/L (based on Luebker *et al. 2005)* was not re-selected for guideline derivation, as a guideline option based on a more recently published, high-quality study was available (NTP 2022) to set a more conservative guideline value for PFOS.	
Options 2 and 3	The guideline options of 27 and 95 ng/L underpinned by Zhong *et al.* (2017) were not selected for guideline derivation as guideline options underpinned by higher certainty evidence were available.	
Option 4	Members agreed that the bone marrow effects (extramedullary haematopoiesis and bone marrow hypocellularity) observed in NTP (2022) was the most critical health effect and the best point of departure to derive a lower, more conservative guideline value for PFOS of 4 ng/L (rounded from 3.4 ng/L to 1 significant figure).	

	Although it was noted there were substantial differences between the modelled Benchmark Dose Level (BMDL) approach and measured no observed adverse effect levels (NOAELs) (i.e. 29-fold difference in female rats and 5-fold difference in male rats), the former was considered to be a more statistically robust approach than the No Observed Adverse Effect Level (NOAEL) approach. This is consistent with the US EPA (2024c), which also applied the BMDL approach when assessing the data from this study.
Option 5	The guideline option of 77 ng/L (based on NTP 2022) was not selected as the health-based guideline value for PFOS as this would raise the current guideline value (to 80 ng/L rounded to 1 significant figure) and a lower, more conservative guideline value for PFOS was available.

*can include other factors/criteria such as those listed in validated tools such as GRADE-DECIDE and WHO-INTEGRATE as required.

Attachment 1: PFOS Evidence Profile (extracted from SLR 2024a, b, c) – to be read in conjunction with Evidence-to-Decision Table

	Option 1	Option 2	Option 3	Option 4	Option 5
Criteria	**Maintain** the current health-based guideline value for PFOS of **70 ng/L**	**Lower** the health-based guideline value for PFOS in drinking water to 27 **ng/L**	**Raise** the health-based guideline value for PFOS in drinking water to **95 ng/L**	**Lower the** health-based guideline value for PFOS in drinking water to **3.4 ng/L**	**Raise** the health-based guideline value for PFOS in drinking water to **77 ng/L**
	Health evidence profile				
Source of Drinking Water Guideline (DWG)	NHMRC and NRMMC 2011, FSANZ 2017	US EPA 2024c	US EPA 2024c	US EPA 2024c	US EPA 2024c

Health-based guidance value (HBGV)	20 ng/kg/day (rounded up from 17)	7.7 ng/kg/day[8] (from $BMDL_{1SD}$)	27 ng/kg/day[8] (from serum NOAEL)	1 ng/kg/day[9](from $BMDL_{10}$)	22 ng/kg/day[9] (from serum NOAEL)
Resulting adaption to a Health-based Drinking Water Guideline (DWG)	70 ng/L	27 ng/L	95 ng/L	3.4 ng/L	77 ng/L
Critical study	**Luebker *et al.* 2005** (developmental toxicity study in pregnant rats)	**Zhong *et al.* 2016** (mice)		**NTP 2022** (rats)	
Proportion of technical/ administrative criteria for potential adoption/ adaption into Guidelines[10]	**High** proportion	**High** proportion		**High** proportion	
Critical Effect	Decreased body weight gain and food consumption in F0 generation (parental toxicity); significant decreased pup weight and	15% decreased plaque forming cell responses (i.e. sheep red blood cell-specific IgM production by B-lymphocytes) of splenic cells in 4-week-old male pups (effect seemed to recover at eight weeks of age).		Extramedullary haematopoiesis and bone marrow hypocellularity	

[8] Due to the relatively wide range of potential $BMDL_{1\,SD}$ values derived by US EPA (2024c) using different BMD models, it is considered appropriate to use the experimental measured serum NOAEL as the POD for adaption of the US EPA (2024c) values for the Australian context. The value that would result from using the $BMDL_{1\,SD}$ value from US EPA (2024c) is considered to be of lower confidence.

[9] The most sensitive effect from the NTP (2022) study is considered to be extramedullary haematopoiesis and bone marrow hypocellularity, as used by US EPA (2024c). Nevertheless, there are large discrepancies between the US EPA (2024c) estimated BMDL10 (2.3 mg/L in female rats, 9.6 mg/L in male rats) and the lowest experimental serum NOAEL achieved in the study (66.97 mg/L in female rats, 51.56 mg/L in male rats), i.e. a 29-fold difference in females, and a 5-fold difference in males. It may therefore be less uncertain to use the measured serum NOAEL from the study as a POD for the critical effects, Thus, higher confidence is placed in the health-based guidance value derived using the experimental NOAEL.

[10] Jurisdiction guidance/guideline met a high (i.e. ~>60%) proportion of 'must-have' and 'should-have' criteria; lower proportions of criteria indicate these guidance documents potentially do not conform with modern methods of undertaking systematic reviews. Full details of the assessment of the FSANZ 2017/NHMRC guidance/guideline is at Appendix D of the Technical Report, and in Appendix B of the Addendum Report for the US EPA (2024c) guidance.

	weight gain during lactation (offspring toxicity).		
Confidence in candidate guideline value	**High** The study appears to have been conducted appropriately, was designed to examine a sensitive effect (i.e. multigeneration study testing relatively large numbers of dose groups and low dose ranges), reported effects as relative to litter, reported serum PFOS concentrations in adults and pups, and examined a large number of endpoints at multiple time points in multiple dose groups.	**Medium** The study appears to have been conducted appropriately, albeit it was of a pilot study nature; it evaluated a large number of immune system markers, as well as hormone levels and clinical parameters. There was a clear dose response for parameters of the immune system to be affected in male mice. US EPA (2024c) also considered the study to be of medium confidence.	**High** This is a comprehensive, high-quality study, has been conducted appropriately and investigated a large number of endpoints. US EPA (2024c) considered the study to be of high confidence.

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Evidence-to-Decision table – Perfluorohexane sulfonic acid (PFHxS) (CAS 355-46-4)

The Evidence-to-Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Water Quality Advisory Committee.

Note that guideline options presented below are unrounded, pending advice from the Committee. However, the chosen guideline option presented in the fact sheet is rounded as per the rounding conventions described in Chapter 6 of the *Australian Drinking Water Guidelines*.

Criteria	OPTION 1: Maintain the current health-based guideline value for PFOS + PFHxS of 70 ng/L *(based on Luebker et al. 2005)*	OPTION 2: Maintain the current health-based guideline value for PFOS + PFHxS of 70 ng/L, with PFHxS not exceeding 34 ng/L *(based on Luebker et al. 2005; NTP 2022)*	OPTION 3: Establish a new health-based guideline value for PFHxS of 34 ng/L *(based on NTP 2022)*	OPTION 4: Establish a new health-based guideline value for PFHxS of 8.5 ng/L *(based on NTP 2022)*
Draft recommendation	*Based on human health considerations, the sum of the concentrations of PFOS and PFHxS in drinking water should not exceed 70 ng/L (0.07 µg/L).*	*Based on human health considerations, the sum of the concentrations of PFOS and PFHxS in drinking water should not exceed 70 ng/L (0.07 µg/L), with the concentration of PFHxS not exceeding 34 ng/L (0.034 µg/L).*	*Based on human health considerations, the concentration of PFHxS in drinking water should not exceed 34 ng/L (0.034 µg/L).*	*Based on human health considerations, the sum of the concentrations of PFOS and PFHxS in drinking water should not exceed 70 ng/L (0.07 µg/L), with the concentration of PFHxS not exceeding 8.5 ng/L (0.0085 µg/L).*

Health evidence profile **(refer to Attachment 1 below for details on each option)**	The SLR (2024a, b) review found that the current Australian guideline value for the sum of PFOS and PFHxS of 70 ng/L in drinking water continues to be considered suitable for guideline derivation. The current NHMRC health-based guideline value of 70 ng/L was published in August 2018. At that time, FSANZ concluded that there was insufficient toxicological and epidemiological evidence to justify establishing a tolerable daily intake (TDI) for PFHxS. However, as a precaution, and for the purposes of site investigations, the PFOS TDI should apply to PFHxS. In practice, this means that the level of PFHxS exposure should be added to the level of PFOS exposure; and this combined level be compared	The SLR (2024a, b) review found that it is reasonable to retain the existing guideline value of 70 ng/L as the sum of PFOS+PFHxS, with PFHxS not exceeding 34 ng/L. Numerous international jurisdictions have derived drinking water guideline values based on different critical health endpoints (some of which are clearly adverse but others which are not necessarily adverse) in animal studies and human epidemiological studies. Three US State jurisdictions (Minnesota-MDH 2020, Michigan-MPART 2019 and California-OEHHA 2022) all derived a guideline value for PFHxS based on decreased thyroxine (T4) in rats. The critical study underpinning this derivation is NTP (2022), and according to the SLR (2024a, b) review, provided appropriate	The SLR (2024a, b) review found that the value of 34 ng/L for PFHxS is suitable for guideline derivation. The review noted that some jurisdictions (e.g. OEHHA, MPART) have a separate guideline value for PFHxS, whilst other jurisdictions (e.g. US EPA, Massachusetts, EU) use a sum of PFAS where PFHxS is included. This option impacts the guideline value for PFOS. If a separate guideline value for PFHxS is established, and the health-based guideline value for PFOS remains at 70 ng/L, it would potentially raise the current sum of PFOS and PFHxS to an overall higher allowable concentration in drinking water of 104 ng/L (i.e. 70 ng/L PFOS and 34 ng/L PFHxS = 104 ng/L PFOS+PFHxS).	Although this guideline option of 8.5 ng/L has been provided as a potential candidate health-based guideline value to adopt/adapt, it is not considered most relevant to the Australian context in terms of selection of uncertainty factors (UFs) and endpoints. Although based on the same study (NTP 2022), it has used the UF composite of 1000, rather than the UF composite of 300 (considered to be suitable for guideline derivation) used by MDH and MPART to derive a drinking water guideline value of 34 ng/L. More information can be found in the PFHxS Evidence profile at **Attachment 1** below.

	to the TDI for PFOS. In the absence of a TDI for PFHxS, FSANZ concluded at that time that it was reasonable to consider that the TDI for PFOS is likely to be conservative and protective of human health as an interim measure.	new information to potentially adopt/adapt for derivation of candidate guidance/guideline values for PFHxS, as the study evaluated a large number of endpoints, provided serum PFHxS concentrations and was conducted in accordance with relevant standardised testing guidelines. More information can be found in the PFHxS Evidence profile at **Attachment 1** below.	It is noted that decreases in thyroid hormones in rodent toxicology studies are generally not considered clinically relevant to humans without a compensatory increase in thyroid-stimulating hormone (TSH) or changes to the pituitary gland observed (SLR 2024a, b). However, evidence of effects of thyroid histopathology in rats was observed by Butenhoff *et al.* (2009) at higher serum PFHxS concentrations. Associations between PFAS exposure and thyroid hormone status were also observed in some human epidemiological studies (e.g. Ballesteros *et al*. 2017; Boesen *et al*. 2020; Coperchini *et al.* 2021). On this basis it is concluded that consideration of the potential human relevancy of the thyroid hormone changes observed in	

			the 28-day NTP (2022) study with PFHxS is appropriate.	
Exposure profile	PFHxS has been detected at concentrations ranging from below detection to 19.1 ng/L in Australian raw and/or reticulated drinking water supplies (QAEHS 2018a, 2018b; Sydney Water 2024; WCWA 2023), including in a study of 33 Australian drinking water samples (Thompson *et al.* 2011). This range of concentrations are below all the candidate health-based guideline values, except option 4. However, PFOS+PFHxS concentration was at 90% of the current Australian health-based guideline value (i.e. ~60 ng/L) in one bore in a drinking water borefield supplying Esperance, Western Australia (SLR 2024a, b). Once this apparent PFOS/PFHxS contamination was identified, this bore was no longer used. This indicates that compliance with the candidate health-based guideline values for PFHxS may present an issue in certain circumstances. Nevertheless, due to the large uncertainty factors and small relative source contribution of 10% incorporated into the derivation of the candidate health-based guideline value, PFHxS is unlikely to present a human health risk from distributed drinking water in most regions of Australia. However, there are many sites of PFAS contamination in Australia, and, if water from these contaminated sites is used as a local source of drinking water (e.g. backyard bore in rural location where distributed water is not available), PFHxS may be present at concentrations greater than the candidate health-based guideline value and the existing Australian health-based guideline value in these cases (SLR 2024a, b). Maximum concentrations of PFHxS in contaminated residential and private bores have been detected between 130 to 54,300 ng/L (AECOM 2017a, 2017b; Bräunig *et al.* 2017; BSC 2021; GHD 2018). The main factor to consider for exposure to PFAS in drinking water is whether drinking water infrastructure is located in the vicinity of potentially contaminating activities. There are many sites of PFAS contamination in Australia, and if water from these contaminated sites is used as a local source of drinking water (e.g. backyard bore in rural location where distributed water is not available), exceedances of PFAS guideline levels may occur (SLR 2024a, b).			
Health benefits vs harms	According to the SLR (2024a, b) review, this guideline option is considered suitable for guideline value derivation; however, it is noted that a	According to the SLR (2024a, b) review, this guideline option is considered suitable for guideline derivation as it is underpinned by a high confidence study.	This option is considered suitable for guideline derivation, however, may have impacts on the guideline	This guideline option is more conservative and protective of health; however, the derivation for this option is not considered most relevant to the Australian

	high quality, recently published study is available for consideration to set a separate guideline value for PFHxS.	Including a separate guideline value for PFHxS may help build awareness and drive health research in this area for this chemical.	value for PFOS and the total sum of both chemicals.	context (see evidence profile at **Attachment 1**).
Values and preferences (consumers, communities)	Human exposure to PFAS is an ongoing concern to consumers and communities, particularly to those who live in communities affected by PFAS. PFAS contamination can have a range of consequences for those affected including impacts on property values, produce, income, reputation and risks to health. Findings from the PFAS Health study showed that people living in PFAS affected communities, irrespective of PFAS blood concentrations, are more likely than those who live in comparison areas to experience psychological distress. It is reasonable to assume that consumers and communities, particularly those experiencing the impacts of contamination, would expect that: • supplied drinking water is safe to drink and that PFAS would not be present in drinking water at levels that might cause harm to public health • new/emerging risks to public health from drinking water are considered by NHMRC and appropriate action is taken depending on the risks to public health • that the selected guideline option will be protective of public health. It is likely that consumers and communities (particularly those affected by PFAS contamination) will continue to be risk-averse to the effects of exposure to PFHxS. Some groups will expect Australia to follow the lead of international agencies that have adopted more conservative guideline values or used different critical health endpoints. While the findings of the NHMRC review should reassure the public that the health evidence has been considered and why a particular guideline value was chosen, clear and consistent public health messaging and plain language risk communication will be required to			

	help explain the differences between international jurisdictions, the difference in guideline value derivation calculations and the NHMRC review process.			
Acceptability (other key stakeholders)	The recent public and media interest in the potential health effects of PFAS will mean that this guideline option might not provide enough certainty to stakeholders such as health regulators and water providers about the level of risk from PFHxS at concentrations found in Australian distributed drinking waters. Although the health evidence for recent changes in international guidance/ guideline values will have been reviewed and critically assessed by NHMRC using best practice review methods for the Australian context, there might be some concerns that NHMRC is not aligning with other international bodies who have decreased their guideline values for PFHxS	Establishing a separate guideline value for PFHxS will provide some confidence to stakeholders about safe levels of PFHxS in drinking water given that new information is now available to derive a guideline value. Factors that might impact acceptability for stakeholders if a separate guideline value for PFHxS is established include: • Potential increased monitoring requirements (especially in contaminated areas) may be less acceptable to water providers given that levels of PFHxS in typical drinking water supplies in Australia have not previously presented health risks (noting that there is limited data available)	While establishing a separate guideline value for PFHxS (34 ng/L) is considered suitable, stakeholders such as health regulators may find this option less acceptable if the guideline value for PFOS remained at 70 ng/L, as it would potentially raise the overall concentration of PFOS and PFHxS allowable in drinking water from 70 to 104 ng/L based on the sum of their separate health-based guideline values. Refer to Option 2 for factors that might impact acceptability for stakeholders if a guideline value is established for PHFxS.	See Option 2. This is the more conservative option. However, as the review (SLR 2024a, b) found the derivation of this candidate guideline value as not as relevant in the Australian context, stakeholders who implement the Guidelines will likely find this option less acceptable. Guideline options that are underpinned by high confidence studies would be more acceptable to stakeholders.

	based on other endpoints if this guideline option is adopted. However, it is noted that there is a high-quality guideline option based on more recently published evidence for thyroid effects (NTP 2022; SLR 2024a, b).	• potential increased regulatory burden for health regulators and/or drinking water authorities as a result of increasing monitoring requirements. Given that the health evidence for recent changes in international guidance/guideline values will have been reviewed and critically assessed by NHMRC using best practice review methods for the Australian context, this guideline option should provide certainty to stakeholders such as health regulators and water providers that PFHxS at concentrations found in Australian distributed drinking waters is unlikely to present a human health risk.		
Feasibility	This guideline option is feasible as no changes to current practice are required.	Establishing a guideline value for PFHxS is technically feasible. According to the SLR (2024a, b) review, the candidate guideline options would be achievable with existing treatment technologies and readily measurable with current commercial analytical techniques. Although existing conventional water treatment technologies do not appear to be particularly effective at removing PFAS from water, the guideline options are/would be achievable if source waters with concentrations below the		

		guideline value are utilised. However, the guideline options may not be achievable for local drinking water supplies in contaminated areas without addition of a PFAS-removal treatment step or use of an alternative water supply.
Health equity impacts	The current guideline value is considered protective of public health for the general population, including groups that may be more sensitive (e.g. infants, children and pregnant women). This also includes populations who may be more exposed to PFHxS based on their proximity to contaminated sites.	
Resource impacts	None. There would be no change in practice if the current guideline value is retained.	Establishing a separate guideline value for PFHxS may have resource impacts on the water sector, however this is unlikely as PFHxS and PFOS are currently measured individually. Establishing a guideline value may result in an increase of exceedances detected in some communities. Through various reporting obligations, water utilities may need to report these exceedances publicly. Additional monitoring and treatment programs (including infrastructure) may be required to treat drinking water supplies to meet guideline values. However, this may only be an issue if using contaminated water supplies, which are not advised to be used. The lower the guideline value, the more treatment will be required. Resulting costs for additional treatment of drinking water supplies or investment in appropriate treatment technologies may be borne by local water providers. In some cases, a new water source may need to be developed to meet guideline values. This may have flow on costs to consumers and communities.
Decision	Decisions regarding the following guideline options by the Water Quality Advisory Committee are outlined below:	
Option 1	A sum of PFOS and PFHxS of 70 ng/L was not selected as it was no longer considered appropriate given that sufficient evidence was available to set a separate guideline value for PFHxS.	
Option 2	A sum of PFOS and PFHxS of 70 ng/L with PFHxS not exceeding 34 ng/L was not selected as it was no longer considered appropriate given that sufficient evidence was available to set a separate guideline value for PFHxS.	

Option 3	Members agreed that there was sufficient toxicological information available to establish a health-based guideline value for PFHxS of 30 ng/L (rounded from 34 ng/L to 1 significant figure) based on thyroid effects observed in rats (NTP 2022).
Option 4	The guideline option of 8.5 ng/L (based on NTP 2022) was not selected for guideline derivation as it was not considered to be the most relevant option for the Australian context in terms of selection of uncertainty factors and endpoints.

*can include other factors/criteria such as those listed in validated tools such as GRADE-DECIDE and WHO-INTEGRATE as required.

Attachment 1: PFHxS Evidence Profile (extracted from SLR 2024a, b) – to be read in conjunction with Evidence-to-Decision Table

	Option 1	Option 2		Option 3	Option 4
Criteria	**Maintain** the current health-based guideline value for PFOS + PFHxS of **70 ng/L**	**Maintain** the current health-based guideline value for PFOS + PFHxS of **70 ng/L,** with PFHxS not exceeding **34 ng/L**		**Establish a new** health-based guideline value for PFHxS of **34 ng/L**	**Establish a new** guideline value for PFHxS of **8.5 ng/L**
Source of Drinking Water Guideline (DWG)	NHMRC and NRMMC 2011, FSANZ 2017	MDH 2020b Minnesota Department of Health	MPART 2019 Michigan's PFAS Action Response Team	MDH 2020b MPART 2019	OEHHA 2022 California Environmental Protection Agency
Health-based guidance value **(HBGV)**	20 ng/kg/day (rounded up from 17)	9.7 ng/kg/day	9.7 ng/kg/day	9.7 ng/kg/day	2.4 ng/kg/day
Resulting adaption to a Health-based Drinking Water Guideline **(DWG)**	70 ng/L (sum of PFOS+PFHxS)	34 ng/L	34 ng/L	34 ng/L	8.5 ng/L[11]
Critical study	**Luebker *et al.* 2005** (rats)	**NTP 2022** (toxicity study in rats)			
Proportion of technical/ administrative criteria for	**High** proportion	**Low** proportion	**Low** proportion (should have);		**High** proportion

[11] Although based on same study (NTP 2022), the difference in value (8.5 to 34) is due to the application of an additional uncertainty factor (UF) - overall composite UF of 1,000 vs 300. However, UF of 300 is considered health protective (refer to p59 of the Evidence Evaluation Report (SLR 2024a, b) for more details).

potential adoption/ adaption into Guidelines[12]			**High** proportion (must have and may have)		
Critical Effect	Decreased bodyweight gain & food consumption in parental generation; decreased pup weight & weight gain during lactation (offspring toxicity).	Decreased T4 (thyroxine) in male rats			
Other comments/ information		The SLR (2024a, b) review noted that in general, the effects in male and female rats administered PFHxS were of lower magnitude (e.g. liver or clinical pathology findings) or not apparent compared to the effects in rats exposed to PFBS and PFOS. Some effects were observed in the liver, however noted to potentially not be relevant to humans. However, the relevance of effects in other organ systems can't be discounted. SLR (2024a, b) noted the uncertainty with respect to human relevancy of the observed thyroid effects based on currently available information and the potential conservatism in any resulting guidance value. It was concluded that potential human relevancy of the thyroid hormone changes observed in the 28-day NTP (2022) study with PFHxS cannot be discounted based on currently available information and in the absence of chronic studies. According to the SLR (2024a, b) review, because the NTP (2022) study was conducted in accordance with relevant standardised testing guidelines, evaluated a large number of endpoints, and provided serum PFHxS concentrations, it is concluded to be appropriate new information to potentially adopt/adapt for derivation of candidate guidance/guideline values for PFHxS.	Although this DWG value of 8.5 ng/L has been provided as a potential candidate option to adapt/adopt, it is not considered most relevant to the Australian context in terms of selection of uncertainty factors (UFs) and endpoints. Although based on same study (NTP 2022), it has used the UF composite of 1000, rather than the UF composite of 300 (considered to be health protective) used by MDH and MPART to derive DWG of 34 ng/L.

[12] Refer to Figure 7-1 Evidence Evaluation Report (p55) for more details (SLR 2024a, b). Jurisdiction guidance/guideline met a high (i.e. ~>60%) proportion of 'must-have' and 'should-have' criteria; lower proportions of criteria indicate these guidance documents potentially do not conform with modern methods of undertaking systematic reviews. Full details of the assessment of the jurisdiction guidance/guideline is at Appendix D of the Technical Report (SLR 2024a, b).

References for PFHxS Evidence-to-Decision Table:

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Evidence-to-Decision table – Perfluorobutane sulfonic acid (PFBS) (CAS 375-73-5)

The Evidence-to-Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Water Quality Advisory Committee.

Note that guideline options presented below are unrounded, pending advice by the Committee. However, the chosen guideline option presented in the fact sheet is rounded as per the rounding conventions described in Chapter 6 of the *Australian Drinking Water Guidelines.*

Criteria	OPTION 1:	OPTIONS 2, 3, 4, 5
	- Maintain status quo (no health-based guideline value for PFBS)	- Establish health-based guideline value for PFBS in drinking water to a guideline value between 1,041 ng/L and 2,939 ng/L *(based on either: Feng et al. 2017; NTP 2022)* (see Attachment 1 below for more information on guideline options for PFBS)

Draft recommendation	*No health-based guideline value is proposed for PFBS.* *PFBS in drinking water would not be a health concern unless concentrations exceeded 1,041 ng/L.*	*Based on human health considerations, the concentration of PFBS in drinking water should not exceed [value of 1,041 ng/L to 2,939 ng/L] [1.04 to 2.94 µg/L].*
Health evidence profile	A review was conducted to identify existing sources of national/international guidance or guidelines on the impact of exposure to PFBS in drinking water on human health outcomes (SLR 2024a, b). The SLR (2024a, b) review found that overt adverse health effects from drinking water exposure to PFBS in humans have not been explicitly recorded in any of the existing guidance/guidelines found suitable to adopt/adapt. However, numerous jurisdictions have derived drinking water guideline values based on different critical health endpoints from animal studies. Where drinking water guideline values have been derived for PFBS, the jurisdictions have agreed that the most sensitive health endpoint is decreased total thyroxine (T4) hormone levels in animal studies (rats). The SLR (2024a, b) review identified reliable toxicological evidence to derive health-based guideline values ranging from **1,041 to 2,939 ng/L**. These potential guideline options were considered as being suitable to adopt/adapt for the Australian context. These candidate guideline options are based on the critical health effect in mice of decreased total thyroxine (T4) hormone levels in female rat offspring on postnatal day 1 (Feng et al. 2017; NTP 2022). These values are also likely conservative due to time of serum collection after the last administered dose; due to the short half-life of PFBS, serum concentrations in dams in both studies may have been 2-3x higher directly after administration of the last dose. Using higher serum concentrations to derive guidance values would also result in higher (i.e. less stringent) guideline values. While the NTP (2022) study was conducted in accordance with relevant standardised testing guidelines and evaluated a large number of endpoints, Feng et al. (2017) was considered to be the best available study as it was considered to have been conducted appropriately and evaluated more sensitive endpoints of interest (i.e. female reproductive performance and developmental effects) (SLR 2024a, b). There is some uncertainty with respect to the human relevancy of the observed thyroid effects in the key studies based on currently available information. The decreased T4 and T3 observed in the NTP (2022) study in rats administered PFBS was not accompanied by increased TSH or thyroid histopathological findings. However, it was noted that a developmental/reproductive toxicity study in mice by Feng et al. (2017) also found decreased T3 and T4 levels at postnatal day 30 which were accompanied by slight but statistically increased serum TSH. As there is a lack of chronic toxicity studies with PFBS, and the Feng et al. (2017) study found increased TSH accompanied the	

	decreased T3 and T4 levels, it is concluded that the potential human relevancy of this effect for PFBS cannot be discounted based on currently available information. Please refer to **Attachment 1** below for the health evidence profile for more details on these guideline options.	
Exposure profile	PFBS concentrations of up to **2.2 ng/L** have been found in Queensland drinking water source waters (QAEHS 2018a, 2018b). There are few PFBS data in drinking water elsewhere in Australia. From the limited amount of literature identified in the public domain from the SLR review (2024a, b), the levels of PFBS in Australian distributed drinking water concentrations are at the low end of concentrations observed in various international jurisdictions (including the US and parts of Europe). Maximum concentrations of PFBS in contaminated residential and private bores has been detected between 40 to 6,520 ng/L (AECOM 2017a, 2017b; GHD 2018. Based on the limited data available, provided drinking water catchments are protected from PFBS contamination and alternative water supplies are available if PFBS contamination is identified, it appears that PFBS concentrations in distributed drinking water in Australia are markedly lower than any of the candidate health-based guideline values, suggesting PFBS is unlikely to present a human health risk from distributed drinking water in Australia. However, there are many sites of PFAS contamination in Australia, and, if water from these contaminated sites is used as a local source of drinking water (e.g. backyard bore in rural location where distributed water is not available), PFBS may be present at concentrations above the candidate health-based guideline values in these cases. The main factor to consider for exposure to PFAS in drinking water is whether drinking water infrastructure is located in the vicinity of potentially contaminating activities. There are many sites of PFAS contamination in Australia, and if water from these contaminated sites is used as a local source of drinking water (e.g. backyard bore in rural location where distributed water is not available), exceedances of PFAS guideline levels may occur (SLR 2024a, b).	
Health benefits vs harms	Given the limited data/information regarding levels of PFBS in Australian distributed drinking water, it is uncertain whether this guideline option will be protective of public health or not given that there is high quality evidence available demonstrating potential health effects.	Establishing a health-based guideline value for PFBS may allow for the generation of datasets to help clarify the level of risk to consumers.

	Information in the PFAS factsheet including uncertainties around actual risks may help build awareness and drive health research in this area. Providing information on a level where health effects might be expected to occur for PFBS may help protect public health in the absence of data/information regarding PFBS chemical levels in Australian distributed drinking water. It may also allow the generation of datasets to help clarify the level of risk to consumers as the health-based target can be used in site investigations and monitoring of water supplies where needed.	
Values and preferences (consumers, communities)	Human exposure to PFAS is an ongoing concern to consumers and communities, particularly to those who live in communities affected by PFAS. For some, knowing that their community is affected by PFAS may increase stress and worry. PFAS contamination can have a range of consequences for those affected including impacts on property values, produce, income, reputation and risks to health. Findings from the PFAS Health study showed that people living in PFAS affected communities, irrespective of PFAS blood concentrations, are more likely than those who live in comparison areas to experience psychological distress. It is reasonable to assume that consumers and communities, particularly those experiencing the impacts of contamination, would expect that: • supplied drinking water is safe to drink and that PFAS would not be present in drinking water at levels that might cause harm to public health • new/emerging risks to public health from drinking water are considered by NHMRC and appropriate action is taken depending on the risks to public health • that the selected guideline option will be protective of public health. It is likely that consumers and communities (particularly those affected by PFAS contamination) will continue to be risk-averse to the effects of exposure to PFAS, including PFBS. To NHMRC's knowledge, consumers have not previously raised concerns specifically about PFBS in drinking water supplies. While the findings of the recent NHMRC evidence review should reassure the public that the health	

	evidence has been considered and why a particular guideline value was chosen, there is likely to be ongoing concern from some groups that Australian advice doesn't align with other international jurisdictions such as the US EPA if a guideline value for PFBS isn't adopted. In addition, there might be an expectation from communities that all PFAS are equally toxic and that guideline values will be derived for all PFAS that are found in Australia. Clear and consistent public health messaging and risk communication, including explanations about the differences between international jurisdictions, guideline value derivations and the review process, could help explain these issues to consumers and reassure them about Australian processes.	
Acceptability (other key stakeholders)	Given that the health evidence has been reviewed and potential candidate guideline options proposed, if this guideline option is adopted, there might be some concerns that NHMRC is not following other international agencies (e.g. Health Canada, EFSA, US EPA, some US States) that have established similar drinking water guideline values for PFBS. Inclusion of information on the level at which health effects might be expected to occur for PFBS chemicals in drinking water might be a more acceptable guideline option to water providers as it provides a health-based target for PFBS chemicals for use in site investigations if needed.	Options to establish a health-based guideline value for PFBS will provide some confidence to stakeholders about safe levels of PFBS in drinking water given that new information is available from which to derive a guideline value, so might be more acceptable from the health protection perspective. Factors that might impact acceptability for stakeholders if a guideline value is established include: • increased testing requirements as a new health-based guideline value may be embedded in the testing requirements for ISO 21675:2019. • increased monitoring requirements may be less acceptable to water providers given that levels of PFBS in typical drinking water supplies in Australia have not previously presented health risks (noting that there is limited data available) • increased regulatory burden for health regulators and/or drinking water authorities as a result of increasing monitoring requirements.

Feasibility	This guideline option is feasible as no changes to current practice are required.	Establishing a guideline value for PFBS is technically feasible. As noted in 'Exposure Profile' above, PFBS concentrations in distributed drinking water in Australia are markedly lower than any of the candidate health-based guideline values. However, the guideline options may not be achievable for local drinking water supplies in contaminated areas without addition of a PFAS-removal treatment step or use of an alternative water supply. According to the SLR (2024a, b) review, the proposed guideline options would be achievable with existing treatment technologies and readily measurable with current commercial analytical techniques.
Health equity impacts	While some of the guideline values under consideration are more conservative than others, all of the guideline options are considered protective of public health for the general population, including groups that may be more sensitive (e.g. infants, children and pregnant women). This also includes populations who may be more exposed to PFBS based on their proximity to contaminated sites.	
Resource impacts	Providing information about a potential level of concern or a health-based target instead of a guideline value for PFBS chemicals may have potential resource impacts if routine monitoring is introduced at specific sites based on the level of risk. This guideline option will likely have less overall resource impacts than establishing a health-based guideline value which will be more broadly implemented. The use of a health-based target will allow for site-specific monitoring of water supplies that might pose the highest risk.	Establishing a guideline value for PFBS may have resource impacts on the water sector. Resources may be required to monitor and test for PFBS in water supplies if a new guideline value for PFBS is introduced in the Guidelines. Establishing a guideline value may result in an increase of exceedances detected in some communities. Through various reporting obligations water utilities may need to report these exceedances publicly. Additional monitoring and treatment programs (including infrastructure) may be required to treat drinking water supplies to meet guideline values. However, this may only be an issue if using contaminated water supplies,

		which are not advised to be used. The lower the guideline value, the more treatment will be required. Resulting costs for additional treatment of drinking water supplies or investment in appropriate treatment technologies may be borne by local water providers. In some cases, a new water source may need to be developed to meet guideline values. This may have flow on costs to consumers and communities.
Decision	Decisions regarding the following guideline options by the Water Quality Advisory Committee are outlined below:	
Option 1	Not setting a guideline value for PFBS was not considered appropriate given that sufficient evidence was available to set a separate guideline value for PFBS.	
Option 2	This option was not considered appropriate as the decreased T4 and T3 observed in the NTP (2022) study in rats administered PFBS was not accompanied by increased TSH or thyroid histopathological findings (as observed in Feng et al. 2017). This indicates there is uncertainty with respect to the human relevancy of the effect based on currently available information from this study.	
Option 3	Members were less comfortable with a guideline value of 2000 ng/L compared to 1000 ng/L as this option incorporated a smaller uncertainty factor and therefore a more conservative guideline value of 1000 ng/L also had a higher margin of safety.	
Option 4	Members agreed to establish a new health-based guideline value for PFBS of 1000 ng/L, equivalent to 1 µg/L (rounded from 1107 mg/L to 1 significant figure) based on thyroid effects observed in mice (Feng et al. 2017). The clinical relevance of the observed decreases in thyroid hormones to humans were supported by these effects being accompanied by a small but statistically significant increase in TSH in mice exposed to PFBS in Feng *et al.* (2017) (SLR 2024a, b).	
Option 5	Members agreed that this particular endpoint is similar to Option 4 and would end up at the same value of 1000 ng/L with rounding.	

*can include other factors/criteria such as those listed in validated tools such as GRADE-DECIDE and WHO-INTEGRATE as required.

Attachment 1: PFBS Evidence Profile (extracted from SLR 2024a, b) – to be read in conjunction with Evidence-to-Decision Table

	Option 1	Option 2	Option 3	Option 4	Option 5
Criteria	**Maintain** status quo (no health-based guideline value for PFBS)	**Establish new** health-based guideline value for PFBS in drinking water of **2,939 ng/L**	**Establish new** health-based guideline value for PFBS in drinking water of **2,252 ng/L**	**Establish new** health-based guideline value for PFBS in drinking water of **1,107 ng/L**	**Establish new** health-based guideline value for PFBS in drinking water of **1,041 ng/L**
Health evidence profile					
Source of Drinking Water Guideline (DWG)	N/A – PFBS not considered by FSANZ 2017	MDH 2022e, g Minnesota Department of Health	OEHHA 2021 Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.	US EPA 2022c, k United States Environmental Protection Agency	MPART 2019 Michigan's PFAS Action Response Team WSDH 2019a, 2022b, 2023a Washington State Department of Health
Health-based guidance value **(HBGV)**	n/a	86 ng/kg/day (840)[13] ng/kg/day	643 ng/kg/day	316 ng/kg/day	297 ng/kg/day
Resulting adaptation to a Health-based Drinking Water Guideline **(DWG)**	n/a	302 (2,939) ng/L	2,252 ng/L	1,107 ng/L	1,041 ng/L
Critical study	n/a	**NTP (2022)** (rats-toxicology study)	**Feng et al. (2017)** (mice – toxicology study)		
Proportion of technical/ administrative criteria for potential adoption/ adaption into Guidelines[14]	n/a	**Low** proportion (must and should have) **High** proportion (may have) MDH 2022g	**High** proportion (must and may have) **Low** proportion (should have)	**High** proportion US EPA 2021c	**Low** proportion (should have); **High** proportion (must and may have) MPART 2019

[13] Two values are provided to indicate the different half-life assumptions used by MDH 2022 compared to NTP (2022) in the derivation. If the half-lives cited in the NTP (2022) study were used, the toxicokinetic adjustment factor, which is very sensitive to the input half-lives assumed for female rats and humans, would change (an order of magnitude difference). The values in brackets are those that would result from using the half-lives cited by NTP (2022). See Section 8.2.1, p63 and Table 8-1, p68-69 of the Evidence Evaluation Report for details (SLR 2024a, b).

[14] Refer to Figure 8-1 Evidence Evaluation Report (p62) for more details (SLR 2024a, b). Jurisdiction guidance/guideline met a high (i.e. ~>60%) proportion of 'must-have' and 'should-have' criteria; lower proportions of criteria indicate these guidance documents potentially do not conform with modern methods of undertaking systematic reviews. Full details of the assessment of the jurisdiction guidance/guideline is at Appendix D of the Technical Report (SLR 2024a, b).

Critical Effect	n/a	Decreased thyroxine (T4) hormone levels in female rats	Decreased total T4 in female rat offspring on postnatal day (PND) PND1
Confidence in candidate guideline value	n/a	As the study was conducted in accordance with relevant standardised testing guidelines and evaluated a large number of endpoints, it is concluded to be appropriate information to potentially adopt/adapt for derivation of candidate guidance/ guideline values for PFBS. It is noted that OEHHA (2021d) considered both the NTP (2022) and Feng et al. (2017) studies for deriving a TRV but **decided against using the NTP (2022) study** because of the large toxicokinetic differences between female rats and humans, and uncertainty around the utility of the rat model for effects in humans of maternal thyroid hormone disruption on foetal development.	As the study was peer reviewed, appears to have been conducted appropriately and evaluated relatively sensitive endpoints of interest (female reproductive performance and developmental effects); it is concluded to be appropriate information to potentially adopt/adapt for derivation of candidate guidance/guideline values for PFBS. The decreased T4 and T3 observed in the NTP (2022) study in rats administered PFBS was not accompanied by increased TSH or thyroid histopathological findings. This indicates there is uncertainty with respect to the human relevancy of the effect based on currently available information. Nevertheless, it is noted that a developmental/reproductive toxicity study in mice by Feng et al. (2017) also found decreased T3 and T4 levels at postnatal day 30 which were accompanied by slight but statistically increased serum TSH. As there is a lack of chronic toxicity studies with PFBS, and the Feng et al. (2017) study found increased TSH accompanied the decreased T3 and T4 levels, it is concluded that the potential human relevancy of this effect for PFBS cannot be discounted based on currently available information.

References for PFBS Evidence-to-Decision Table:

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SLR (2024a). Evidence Evaluations for Australian Drinking Water Guidelines Chemical Fact Sheets – PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals. Evaluation and Technical Reports prepared for the National Health and Medical Research Council. SLR Consulting Australia. 1 February 2024.

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Evidence-to-Decision table – GenX Chemicals - hexafluoropropylene oxide ammonium salt (CAS No 62037-80-3) plus hexafluoropropylene oxide dimer acid (CAS No 13252-13-6)

The Evidence-to-Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Water Quality Advisory Committee.

Note that guideline options presented below are unrounded, pending advice from the Committee. However, the chosen guideline option presented in the fact sheet is rounded as per the rounding conventions described in Chapter 6 of the *Australian Drinking Water Guidelines*.

Criteria	OPTION 1: Maintain status quo (no health-based guideline value for GenX chemicals)	OPTION 2: - No health-based guideline value for GenX chemicals - Provide information on health effects that might occur > [*12 or 263 ng/L*] (including derivation of a potential health-based target)	OPTION 3: Establish health-based guideline value for GenX chemicals [*12 or 263 ng/L*] *(based on Dupont 2010)*
Draft recommendation	*No health-based guideline value is proposed for GenX chemicals.*	*No health-based guideline value is proposed for GenX chemicals.* *GenX chemicals in drinking water would not be a health concern unless concentrations exceeded [12 or 263 ng/L].*	*Based on human health considerations, the concentration of Gen X chemicals in drinking water should not exceed [12 or 263 ng/L] [0.012 or 0.26 µg/L].*
Health evidence profile	A review of existing sources of national/ international guidance or guidelines found that there is	Although the SLR (2024a, b) review found insufficient evidence to derive a health-based guideline value for GenX chemicals, a	See health evidence profile for guideline option 2.

	currently insufficient health evidence to derive a health-based guideline value for GenX chemicals in drinking water (SLR 2024a, b). Most jurisdictions that were reviewed have not set a guideline value for GenX chemicals in drinking water. Several guidance/guidelines set by agencies in the United States were found suitable to adopt/adapt based on administrative and technical processes assessed in the review. However, these were found to be informed by a single industry-funded study (Dupont 2010), which may affect the quality of the study due to conflict of interest and risk of bias. It is uncertain if this option will be protective of health given that no information on levels of GenX chemicals in Australian water supplies were identified in the review.	concentration of potential concern (12 or 263 ng/L) can be derived based on the limited toxicity data available. According to the review, overt adverse health effects from drinking water exposure to GenX chemicals in humans were not explicitly recorded in any of the existing guidance/guidelines found suitable to adopt/adapt. However, where drinking water guideline values have been derived for GenX chemicals in the United States, the relevant agencies agreed that the most sensitive health endpoint is liver effects (increased absolute and relative liver weight and histopathological changes in the liver) from a single unpublished reproductive/ developmental toxicity study in mice (DuPont 2010). The difference in the different levels of concern under consideration (12 vs 263 ng/L) is a result of adopting uncertainty factors used by MPART (2019) or the US EPA (2021, 2022). The US EPA applies higher uncertainty factors for study timeframe and limited database (i.e. a UF of 10 instead of 3 applied by MPART (2019)), resulting in a much lower guideline value of 12 ng/L. According to the findings of the review, using higher uncertainty factors for both study	It is uncertain if this guideline option will be protective of health as there is only one unpublished toxicological study available on which to base a candidate health-based guideline value. While the US EPA and other agencies in the United States have found the study suitable to use for deriving drinking water guideline values, there are some methodological issues, including potential risk of bias and the need for the source evidence to be publicly available.

		timeframes and databases is not considered warranted. As a result, the lower guideline option (12 ng/L) was found to be less relevant to the Australian context. While the US EPA (2021e, 2022c) and other agencies found that the Dupont (2010) study was well conducted, there are some concerns about the study methods, such as a lack of transparency regarding the source evidence and potential risk of bias (e.g. confounding issues with the purity of the chemical tested, industry funding).	
Exposure profile	The SLR (2024a, b) review found that concentrations of GenX chemicals in overseas distributed drinking waters (<5 ng/L) are much lower than the concentrations of potential concern. No information regarding GenX chemical levels in Australian distributed drinking water was identified from the literature retrieved. While the import and industrial use of GenX chemicals in Australia has not been approved through the Australian Industrial Chemicals Introduction Scheme, it is possible that these chemicals may be present in Australia as trace residues in/on products that may end up in landfill and leach into water supplies at low levels. It is unknown whether GenX chemicals are present in Australia at concentrations lower or higher than the candidate health-based guideline values. It is suggested additional research is needed to determine whether GenX chemicals are found in any Australian source waters or drinking waters, which would also inform whether a health-based guideline value is required.		
Health benefits vs harms	Given the lack of data/information regarding GenX chemical levels in Australian distributed drinking water, it is uncertain whether this guideline option will be protective of public health or not.	Providing information about levels where health effects might be expected to occur for GenX chemicals may help protect public health in the absence of data/ information regarding GenX chemical levels in Australian distributed drinking water. It may also allow the generation of	Establishing a health-based guideline value for GenX chemicals will be protective of public health in the absence of data/ information regarding GenX chemical levels in Australian distributed drinking water. It may also allow

	Information in the PFAS factsheet including uncertainties around actual risks may help build awareness and drive health research in this area.	datasets to help clarify the level of risk to consumers as the health-based target can be used in site investigations and monitoring of water supplies. Using a health-based target of 10 ng/L would be a more conservative option. However, the derivation for this option is not considered most relevant to the Australian context (see evidence profile).	the generation of datasets to help clarify the level of risk to consumers.
Values and preferences (consumers, communities)	Human exposure to PFAS is an ongoing concern to consumers and communities, particularly to those who live in communities affected by PFAS. For some, knowing that their community is affected by PFAS may increase stress and worry. Findings from the PFAS Health study showed that people living in PFAS affected communities, irrespective of PFAS blood concentrations, are more likely than those who live in comparison areas to experience psychological distress. PFAS contamination can have a range of consequences for those affected including impacts on property values, produce, income, reputation and risks to health. It is reasonable to assume that consumers and communities, particularly those experiencing the impacts of contamination, would expect that: • supplied drinking water is safe to drink and that PFAS would not be present in drinking water at levels that might cause harm to public health • new/emerging risks to public health from drinking water are considered by NHMRC and appropriate action is taken depending on the risks to public health • that the selected guideline option will be protective of public health. It is likely that consumers and communities will be very risk adverse to the effects of exposure to GenX chemicals. While the findings of the NHMRC review should reassure the public that the health evidence has been considered any why a particular guideline value was chosen (or not), there is likely to be ongoing concern from some groups that Australian advice doesn't align with other international agencies such as the US EPA if a guideline value isn't adopted. The uncertainty around the presence of GenX chemicals in Australian water supplies and		

	the evidence base may increase concerns. In addition, there might be an expectation from communities that all PFAS are equally toxic and that guideline values will be derived for all PFAS that are found in Australia, including newer substances such as GenX chemicals. Clear and consistent public health messaging and risk communication, including explanations about the differences between international jurisdictions, guideline value derivations and the review process, could help explain these issues to consumers and reassure them about Australian processes.		
Acceptability (other key stakeholders)	Given that the SLR (2024a, b) review found that there is currently insufficient evidence to derive a health-based guideline value for GenX chemicals, this option would likely be acceptable to stakeholders. Setting a health-based guideline value that would result in a change in practice without a clear body of evidence would not be readily supported by health regulators or water providers.	Inclusion of information on the level at which health effects might be expected to occur for GenX chemicals in drinking water could provide some confidence to stakeholders who implement the Guidelines from a health protection perspective, as it will provide a health-based target for GenX chemicals for use in site investigations if needed. However, ready access to testing for GenX chemicals may take some time, as according to the SLR (2024a, b) review, GenX chemicals are not routinely measured by Australian laboratories and have only recently been added to analytical schedules offered by some commercial laboratories. Factors that might impact acceptability of a health-based target of potential concern for GenX chemicals include:	Establishment of a health-based guideline value for GenX chemicals could provide some confidence to stakeholders from a health protection perspective. However, the routine monitoring of GenX chemicals would take some time to implement, as according to the SLR (2024a, b) review, GenX chemicals are not routinely measured by Australian laboratories and have only recently been added to analytical schedules offered by some commercial laboratories. Factors that might impact acceptability of a health-based guideline value for stakeholders include: • increased testing requirements as GenX chemicals are currently not routinely measured by Australian laboratories • increased monitoring requirements may be less acceptable to water providers, particularly if the review found limited

		• increased testing requirements as GenX chemicals are currently not routinely measured by Australian laboratories • increased regulatory burden for health regulators and/or drinking water authorities as a result of increasing monitoring/measuring requirements.	evidence for establishing the health-based guideline value • increased regulatory burden for health regulators and/or drinking water authorities as a result of increasing monitoring/measuring requirements.
Feasibility	This guideline option is feasible as no changes to current practice are required.	Including a health-based target or establishing a health-based guideline value may be feasible as these levels would be readily measurable with current commercial analytical techniques. However, as GenX chemicals are not routinely measured by Australian laboratories and have only recently been added to analytical schedules offered by some commercial laboratories, it is likely to be resource-intensive to commence measurement and may take time to implement routine monitoring if required.	
Health equity impacts	While some of the values under consideration are more conservative than others, all of the guideline options are considered protective of public health for the general population, including groups that may be more sensitive (e.g. infants, children and pregnant women). This also includes populations who may be more exposed to PFAS based on their geographical location or socioeconomic status.		
Resource impacts	None. There would be no change in current practice if no guideline value is established.	This guideline option will likely have less overall resource impacts than establishing a health-based guideline value which will be more broadly implemented. The use of a health-based target will allow for site-specific monitoring of water supplies that might pose the highest risk. Providing information about a potential level of concern or a health-based	Establishing a health-based guideline value for GenX chemicals will have resource impacts on the water sector. Additional testing services would be required as GenX chemicals are not routinely measured by Australian laboratories and have only recently been added to analytical schedules offered by some commercial laboratories.

		target instead of a guideline value for GenX chemicals may have potential resource impacts if routine monitoring is introduced at specific sites based on the level of risk.	Additional widespread monitoring and potentially treatment programs (including infrastructure) may be required to meet the candidate guideline value if exceedances are detected. Through various reporting obligations water utilities may need to report these exceedances publicly. Resulting costs for additional monitoring of drinking water supplies or investment in appropriate measurement and treatment technologies may be borne by local water providers. In some cases, a new water source may need to be developed to meet guideline values. This may have flow on costs to consumers and communities. However, this may only be an issue if using contaminated water supplies, which are not advised to be used.
Decision	Decisions regarding the following guideline options by the Water Quality Advisory Committee are outlined below:		
Option 1	Members agreed to not establish a health-based guideline value for GenX chemicals. Members noted that given the limited evidence available, further toxicological information would be needed before Members would be comfortable setting a health-based guideline value for GenX chemicals.		
Option 2	This option was not considered appropriate as further toxicological information would be needed before Members would be comfortable providing information on a health-based guideline value for GenX chemicals.		

Option 3	This option of establishing a health-based guideline value (of *12 or 263 ng/L)* was not considered appropriate given the limited evidence available and concerns about conflicts of interest of the underpinning study.

*can include other factors/criteria such as those listed in validated tools such as GRADE-DECIDE and WHO-INTEGRATE as required.

Attachment 1: GenX Chemicals Evidence Profile (extracted from SLR 2024a, b) – to be read in conjunction with Evidence-to-Decision Table

	Option 1	**Option 2**	**Option 3**	
Criteria	**Maintain** status quo (no health-based guideline value for GenX chemicals)	**Maintain** status quo (no health-based guideline value for GenX chemicals) Provide information on health effects that might occur >[12 or 263 ng/L]	**Establish new** health-based guideline value for GenX chemicals in drinking water of **263 ng/L**	**Establish new** health-based guideline value for GenX chemicals in drinking water of **12 ng/L**
Health evidence profile				
Source of Drinking Water Guideline (DWG)	N/A – GenX chemicals not considered by FSANZ 2017	N/A – GenX chemicals not considered by FSANZ 2017	MPART 2019 Michigan's PFAS Action Response Team	US EPA 2021e, 2022c, j; WSDH 2022, 2023a; NJDEP 2023a United States Environmental Protection Agency; Washington State Department of Health
Health-based guidance value (HBGV)			75 ng/kg/day	3.3 ng/kg/day
Resulting adaptation to a Health-based Drinking Water Guideline (DWG)			263 ng/L	12 ng/L
Critical study			**Dupont (2010)** (mice study)	

Proportion of technical/ administrative criteria for potential adoption/ adaption into Guidelines[15]			**High** proportion	**High** proportion (US EPA 2021e)
Other comments/ information			SLR (2024a, b) noted that there is only one toxicological study available on which to base a candidate DWG. There is also concern with respect to the reported purity (i.e. 84%) of GenX in the DuPont (2010) study.	

References for GenX Chemicals Evidence-to-Decision Table:

Dupont (2010). Oral (gavage) reproduction/developmental toxicity study in mice (OECD TG 421; modified according to the Consent Order) DuPont-18405-1037. Unpublished. As cited in MPART 2019a.

FSANZ (2017). Hazard Assessment Report: Perfluorooctane sulfonate (PFOS), Perfluorooctanoic acid (PFOA) and Perfluorohexane sulfonate (PFHxS). Food Standards Australia New Zealand. Australian Government.

MPART (2019). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).

SLR (2024a). Evidence Evaluations for Australian Drinking Water Guidelines Chemical Fact Sheets – PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals. Evaluation and Technical Reports prepared for the National Health and Medical Research Council. SLR Consulting Australia. 1 February 2024.

SLR (2024b). Evidence Evaluations for Australian Drinking Water Guidelines Chemical Fact Sheets – PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals. Technical Report prepared for the National Health and Medical Research Council. SLR Consulting Australia. 1 February 2024.

[15] Refer to Figure 10-1 Evidence Evaluation Report (p87) for more details (SLR 2024a, b). Jurisdiction guidance/guideline met a high (i.e. ~>60%) proportion of 'must-have' and 'should-have' criteria; lower proportions of criteria indicate these guidance documents potentially do not conform with modern methods of undertaking systematic reviews. Full details of the assessment of the jurisdiction guidance/guideline is at Appendix D of the Technical Report (SLR 2024a, b).

USEPA (2021e). Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3). Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: 822R-21-010. October 2021. United States Environmental Protection Agency (USEPA).

US EPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).

WSDH (2022). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (WSDH).

WSDH (2023). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (WSDH).

Appendix B – Targeted consultation feedback

The enHealth Water Quality Expert Reference Panel (WQERP), the Department of Health and Aged Care and Food Standards Australia New Zealand (FSANZ) were formally consulted between 2-10 September 2024 on the draft targeted consultation guidance related to the revised chemical fact sheet for per- and polyfluoroalkylated substances (PFAS) as part of the rolling revision of the *Australian Drinking Water Guidelines* (the Guidelines).

As part of the consultation, NHMRC sought feedback on the following questions:

1. Is the draft guidance relevant, accurate and easy to understand?
2. Do you support the approaches taken to review the evidence and develop the guidance?
3. Do you have any other comments about implementation or feasibility of the proposed health-based guideline values?

The opportunity to provide specific comments and/or tracked changes in the documents was also provided.

Summary of feedback received

Feedback received from the Department, FSANZ and WQERP suggested a number of proposed revisions to the draft Fact Sheet, the review reports, the evidence to decision tables, the NHMRC Statement and the Questions and Answer (Q&A) resource. In some instances, specific edits were made to clarify or simplify the language used as well as include additional references within the draft Fact sheet. Some common areas of feedback included:

- concerns around the toxicological basis, the choice of studies and endpoints and uncertainty factors in deriving the health-based guideline values
- the approach of considering different candidate values (‘guideline options’) for the same chemical and presenting them as equally health protective (in the evidence review reports and evidence-to-decision tables), stating that this apparent flexibility in the guideline value derivation process may be confusing for end users

- comments relating to implementation and feasibility within jurisdictions of proposed new health-based guideline values, and potential compliance issues in some areas near to contaminated areas
- raising the likelihood of impacts on other PFAS guidance values (e.g. FSANZ tolerable daily intake values that are the basis for food trigger points and soil guidelines) if any proposed changes to NHMRC advice are accepted and adapted by other Australian guidelines or agencies
- the various PFAS exposure pathways and relative contribution of drinking water, commenting that drinking water is just one of many significant sources represented by personal care products, food, food packaging, many consumer goods, clothing, air and dust
- information about typical levels of PFAS detected in drinking water and citing recent data from utilities
- concerns that the level of detail included in the draft Fact Sheet, particularly in the health considerations section, and the potential for it to be considered too technical and lengthy for the average reader of the Guidelines
- technical questions and clarifications about the evidence review reports.

Suggestions to improve the clarity and accuracy of potential questions and answers for stakeholders were also provided.

Detailed feedback from the Department, FSANZ and WQERP, with the exclusion of minor edits and typographical corrections, is captured in the table below, noting that some comments were provided in marked up versions of the draft documents.

Targeted consultation feedback on the draft PFAS fact sheet and supporting information

#	Relevant section	Feedback received	Action/Response
Question 1: Is the draft guidance relevant, accurate and easy to understand?			

1	-	The guidance is relevant and appears to be accurate but as to the extent to which it is easy to understand, the answer is that it depends on the reader's technical proficiency with respect to toxicology and understanding of the NHMRC's guideline development processes. To be honest these processes can be quite hard to follow for readers without a background in the field. However, the reality is that it would take an enormous amount of explanatory material to get "average" readers up to speed with this field of scientific endeavour and so "easy to understand" is likely to remain a stretch.	Noted. The fact sheet and the supporting review reports provide more technical information about the complex review process used to review the PFAS fact sheet. It is intended that supporting information such as the Q&A resource, the NHMRC Statement and other comms materials will provide some clarification on the process for lay readers. These documents can be readily updated as more questions arise if necessary.
2	-	The draft Fact Sheet is relevant, easy to understand and accurate.	-
3	-	Request that NHMRC also make a public statement addressing the implications of a potential change in guideline values.	Noted. NHMRC Statement developed from existing Review Summary.
4	-	No major concerns with the guidance from us.	-
Question 2: Do you support the approaches taken to review the evidence and develop the guidance?			
5	-	I am satisfied that the proposed draft GVs for the nominated PFAS chemicals are based on high quality studies, resulting in a high level of confidence in the scientific rigour of the candidate guideline values. The approach whereby different candidate values ("options") for the same chemical are presented as having equal justification, and therefore being *equally* protective of human health is a problematic one. Many	Noted. NHMRC has developed a more streamlined approach for considering guideline values that have recently been reviewed by other agencies. Those guidelines found suitable to adopt/adapt based on their administrative and technical guideline development processes are collated in the review reports and

		general readers will not respond well to this apparent "flexibility" in the guideline setting process. I acknowledge that single values for the main PFAS chemicals are put forward up front in the Factsheet but the multiple options in the Evidence to Decision documents can be a little confusing.	presented for consideration by NHMRC and the Water Quality Advisory Committee. While it may be confusing to see a range of guideline options in the review reports and evidence to decision tables, they are intended to demonstrate how the Water Quality Advisory Committee have made their decisions and what they have considered alongside the health evidence to determine why/why not certain guideline options were accepted or not. This is based on an understanding of the certainty in the underpinning toxicological studies, whether the chosen endpoints are clinically relevant and which end points are considered the most critical and protective of health. This will be clarified in the Q&A resource.
6	-	I support the approaches taken in developing the HBGV.	-
Question 3: Do you have any other comments about implementation or feasibility of the proposed health-based guideline values?			
7	-	I know there is some urgency in some sections of the scientific community, as well as in the media, to deal with PFAS in drinking water by taking a very conservative approach to guideline values but, by the same token, drinking water represents a very small proportion of most Australians' exposure to potentially harmful PFAS chemicals. It is therefore difficult to justify urgent and possibly very expensive action to	Noted. PFAS exposure occurs through many different pathways, and this has been mentioned in the fact sheet and supporting information. Information on how the Guidelines are implemented by the states/territories is already within the Guidelines, but also noted within the supporting documentation for this

		reduce levels in drinking water when very little appears to be happening to the other, much more significant, sources represented by personal care products, food, food packaging, many consumer goods, clothing, air and dust (this last one being significant for small children). Therefore, there appears to be a case for the ADWG to acknowledge that while guideline values do not, in themselves, need to be phased in, each jurisdiction should be entitled to exercise a risk-based approach to implementation of the new ADWG values for PFAS. This may help to guarantee that resources are not diverted away from more realistic and salient harms, to what is, in many parts of Australia, a negligible risk to the safety of drinking water.	update such as the NHMRC Statement and the Q&A resource, where it may be more appropriate to discuss than the draft fact sheet.
8	-	Comments relating to implementation and feasibility: • Requires regulator discussion as to a monitoring approach – does it neatly fit under the risk assessment framework of the ADWG – thereby no testing is required if not identified as a catchment risk • Consideration in messaging for a comparison between USEPA limits and ADWG – reasons why they are different • Acknowledgement of the different landscape of the USEPA – time provided to start testing before limits are enforced.	Noted. Monitoring approaches are likely to be jurisdiction-based and site-specific. Further discussion may be required to determine whether any additional monitoring advice on approaches will be useful or appropriate in the Guidelines. Any proposed changes supported by jurisdictions can be considered by NHMRC with advice from the Water Quality Advisory Committee. Monitoring and implementation are addressed in the NHMRC Statement. Differences between guideline values and approaches are acknowledged in the NHMRC Statement and Q&A resource.

9	-	• Changing the DWG means the reference dose or tolerable daily intake will officially change as that value is the basis for the new DWG. • The fact sheet lists the new TDI as 1.2 ng/kg bw/day compared to the current one which is 20 ng/kg bw/day (i.e. around 20-fold lower). • This TDI is essentially background (Thompson et al. 2010). Estimated intakes ranged from1.6–3.8 ng/kg bw/day for PFOS based on pools collected in 2002–2003, and 1.7–3.6 ng/kg bw/day for those collected in 2006–2007. Setting TDI at background level does not allow for any exceedances from other exposure pathways. • ***The current Australian TDIs from FSANZ work are the basis for food triggers points and soil guidelines etc. So, changing the TDI not only changes the DWG it must result in a change in ALL the other guidelines.*** • The FSANZ trigger points would also go down by around 20-fold which will mean food will generally not comply. The last FSANZ total diet survey (FSANZ 2021) did look for PFAS. They did detect low levels in some samples. The updated trigger points would be less than the common LORs – i.e. unimplementable. (particularly fish and meat).	Noted. The tolerable daily intake used by other agencies might not change as a result of the NHMRC review – this is up to the relevant agencies. The scope of the NHMRC review was to determine whether changes in NHMRC advice in the Guidelines were warranted. Further review of guidance values other than drinking water is outside the scope of this review; however, it is noted that there will be impacts on other PFAS guidance values if any proposed changes to NHMRC advice are considered, accepted and adapted by other Australian guidelines or agencies. Review reports and draft fact sheet have been revised to reflect final advice from the Water Quality Advisory Committee. It is also noted that the proposed changes to guideline values are out for public consultation and may change pending public submissions, further expert review and publication of further evidence (such as the International Agency for Research on Cancer (IARC) monograph) before the guideline values are finalised. Recreational water quality guidelines for PFAS will be reviewed as part of the general update

		• Recreational water quality guidelines in Australia are based on DWGs so changing the DWG will change the recreational guideline to a value of around 100 ng/L instead of the current 2,000 ng/L. This will result in a multitude of waterways in urban areas being no longer acceptable for swimming.	to those guidelines and pending finalisation of advice for drinking water.

#	Relevant section	Feedback received	Action/Response
General comments (draft Fact Sheet and Review Reports):			
10	-	I recommend that reference is made to the fact that these PFAS GVs define water that is safe to drink over a lifetime based on current knowledge (page 7, ADWG). This is implied in the use of chronic studies or non-chronic to chronic UFs in deriving the GVs, but it would be good to reiterate given public concern.	Accepted. This point is included in NHMRC Statement and Q&A resource, and already defined in the Guidelines.
11	General description	"PFAS are persistent in the environment, show the potential for bioaccumulation and biomagnification, and are toxic in animal studies (e.g. potential developmental, reproductive and systemic toxicity)." Is blanket statement appropriate for all thousands of PFAS compounds, some of which toxicological data is scarcely available for? Suggest qualifying to: "**Some** PFAS are persistent in the environment, ... toxicity)."	Accepted. Text amended.

12	General description	Given the word/label "GenX" doesn't follow the usual pattern for abbreviating the name of a PFAS chemical, would it be possible to add somewhere in the document, why the label/name "GenX" is used? Hexafluoropropylene oxide dimer acid (HFPO-DA) and its ammonium salt are labelled as "GenX" because they are the primary chemicals used in the GenX processing aid technology. This technology was developed as a replacement for perfluorooctanoic acid (PFOA). The name "GenX" reflects the next generation of fluoropolymer manufacturing processes that aim to be safer and more sustainable.	Accepted. Suggested wording added to information for GenX under 'Levels detected in Australian drinking water' section.
13	General description	Is there enough evidence for biomagnification?	Noted. Edits made to provide reference for biomagnification.
14	General description	"PFAS have also been found in groundwater, surface water, sewage effluents and landfill leachates in international studies (Ahrens et al. 2016; Banzhaf et al. 2017)." Should Australian studies be included? i.e., Hue T. Nguyen, Phong K. Thai, Sarit L. Kaserzon, Jake W. O'Brien, Jochen F. Mueller, (2024) Nationwide occurrence and discharge mass load of per- and polyfluoroalkyl substances in effluent and biosolids: A snapshot from 75 wastewater treatment plants across Australia, Journal of Hazardous Materials, 470:134203. https://doi.org/10.1016/j.jhazmat.2024.134203. C. Gallen, G. Eaglesham, D. Drage, T. Hue Nguyen, J.F. Mueller, (2018) A mass estimate of perfluoroalkyl substance (PFAS) release from Australian wastewater treatment plants,	Accepted. References added.

		Chemosphere, 208;975-983. https://doi.org/10.1016/j.chemosphere.2018.06.024. C. Gallen, D. Drage, G. Eaglesham, S. Grant, M. Bowman, J.F. Mueller (2017) Australia-wide assessment of perfluoroalkyl substances (PFASs) in landfill leachates, Journal of Hazardous Materials, 331:132-141. https://doi.org/10.1016/j.jhazmat.2017.02.006.	
15	General description	Would it be worth including information on the PFAS ban/restriction under DCCEEW's Industrial Chemicals Environmental Management Standard (IChEMS) - to commence on 1 July 2025?	Accepted. Reference to IChEMS added.
16	General description	"Humans can be exposed to PFAS present in sources such as food, consumer products, dust and drinking water (Health Canada 2024)." Should attribution be assigned to indicate that estimates of exposure via drinking water for a non-exposed community (i.e. not impacted by a point source) are ~3% (Thompson et al. 2011)	Accepted. Reference and suggested text added.
17	Levels detected in Australian drinking water	Do we need this? People will argue with it, but it seems historical.	Noted. Text retained, as this is a standard section in chemical factsheets and provides some indication of levels in drinking water that provide information on potential exposure for the risk assessment.
18	Levels detected in Australian drinking water	Considering current consideration of biomonitoring program proposal, suggest using 'to date' rather than usually.	Accepted. Text amended and reference to biomonitoring removed due to lack of relevance for this section of the fact sheet.

19	Levels detected in Australian drinking water	Queensland has had a bi-annual PFAS biomonitoring (blood serum) campaign conducted via UQ since 2001 (Toms et al. 2014, below,, and continually until 2024 (see Case Study - Per- and Poly-fluoroalkyl Substances (PFAS) - Queensland Alliance for Environmental Health Sciences - University of Queensland (uq.edu.au). The question is whether the biomonitoring is relevant in this context if not explained / elaborated further. **If not, suggest deleting the "and biomonitoring"** L.-M.L. Toms, J. Thompson, A. Rotander, P. Hobson, A.M. Calafat, K. Kato, X. Ye, S. Broomhall, F. Harden, J.F. Mueller, (2014) Decline in perfluorooctane sulfonate and perfluorooctanoate serum concentrations in an Australian population from 2002 to 2011, Environment International, 71:74-80. https://doi.org/10.1016/j.envint.2014.05.019.	Noted. Reference to biomonitoring removed due to lack of relevance for this section of the fact sheet.
20	Levels detected in Australian drinking water	See Sydney water 2024 monitoring results https://www.sydneywater.com.au/water-the-environment/how-we-manage-sydneys-water/safe-drinking-water/water-analysis/pfas-and-drinking-water.html Also, Hunter water publish results online https://www.hunterwater.com.au/about-us/publications/regulatory-reports Some water utilities carry out regular monitoring due to the proximity of their raw water to PFAS contamination sites. Some other water utilities now include PFAS in monitoring programs, even when there is no identified source of contamination. Please	Accepted. Text amended and will be updated pending more recent data that may become available following public consultation.

		consider and cite most recent Sydney Water monitoring results before releasing for public consultation https://www.sydneywater.com.au/water-the-environment/how-we-manage-sydneys-water/safe-drinking-water/water-analysis/pfas-and-drinking-water.html	
21	Levels detected in Australian drinking water	For Vic waterways and potential drinking water sources https://www.epa.vic.gov.au/about-epa/publications/2049-report-on-pfas-in-the-environment is a useful link if not considered already	Noted. Text to be updated pending more recent data that may become available following public consultation.
22	Levels detected in Australian drinking water	'Low concentrations of PFAS have been detected in water supplies not impacted by contaminated sites (see below).' Suggest rewording this slightly. Guessing that when mentioning contaminated sites this refers to an established site with known contamination. It would be great to word in a way to highlight PFAS is being found in locations with no obvious source of contamination.	Noted. Text already mentions detections at sites with no obvious contamination.
23	Levels detected in Australian drinking water	Suggest removing the lower bound of the ranges for PFOA, PFHxS and PFBS, and restructuring the sentences to "X has been detected in concentrations up to Y ng/L in Z". For these three compounds, the minimum is lower than the proposed GV. This has the effect of making it seem that some contamination is deemed "safe", which can confuse readers.	Noted and minor changes made to clarify. Providing a range shows the variability and also that low concentrations can also be found at these sites (i.e. that they're not all up to the max range, i.e. 10,500 for PFOA).

24	Levels detected in Australian drinking water	The "QAEHS 2018a,b" references refer to water sampled from raw water catchments (pre-treatment) and not reticulated drinking water supplies. Suggest to either remove the references (and assess if the max concentration provided is still accurate) or include / indicate the raw water sampled in the sentence.	Accepted. Text amended.
25	Levels detected in Australian drinking water	In each of the chemical headings the wording used for residential and private bores is "can range between" as they are only presenting measured values. More correct wording would be "…has been detected at…"	Accepted. Text amended to clarify.
26	Levels detected in Australian drinking water	Could add the following reference with levels for PFOS and PFHxS reported within the range mentioned, if helpful: Jennifer Bräunig, Christine Baduel, Amy Heffernan, Anna Rotander, Eric Donaldson, Jochen F. Mueller, (2017), Fate and redistribution of perfluoroalkyl acids through AFFF-impacted groundwater, Science of The Total Environment, 596–597:360-368. https://doi.org/10.1016/j.scitotenv.2017.04.095.	Accepted. Reference added to PFOS and PFHxS sections.
27	Levels detected in Australian drinking water	Is it confirmed with fire authorities that they are not using GENX foams in Australia?	Noted. Sentence removed until confirmed.
28	Treatment of Drinking Water	Re. home water treatment….this could remove/reduce fluoride and lead to increased tooth decay	Accepted. Text added to note potential removal of beneficial chemicals.
29	Measurement	Suggest including 'in line with accepted guidelines' in sentence, as in: PFAS sample collection and analysis should be carried out by	Accepted. Text amended.

		trained personnel **in line with accepted guidelines and** with appropriate quality control samples.	
30	Health considerations	While the content here is useful for some risk assessors, and some detailed discussion is warranted (e.g. PFOA carcinogenicity), for the majority of the ADWG's audience the current text is rather technical and lengthy. Currently much of pages 4-10 reads like a toxicological defence of the new GVs as of the year 2024 rather than a typical ADWG factsheet. I suggest the text is more concise by leaving in only the key details, by reducing the number of individual studies that are mentioned, and reducing the number of statements etc. In particular, the last three paragraphs on page 5 (starting with: "International jurisdictions have developed…". The paragraph on the IARC classifications (page 4) could be condensed to one or two sentences, following the same format for other parameters in the ADWG with IARC classifications. As another example, Under Epidemiological studies for PFOA, the specific limitations of the human epi studies could be removed.	Not accepted. The Water Quality Advisory Committee advised to present this information differently than typical fact sheets given the interest in overseas advice and public expectations. The information is intended to help provide the rationale leading to the choices in endpoints and studies for guideline derivations. Overall IARC classifications provided here for context and comparison with ANU study before discussing in more detail for individual chemicals. Providing the limitations of epidemiological studies are important to justify why they haven't been used to derive a guideline value.
31	Health considerations	I suggest that this section and reference to IARC is reviewed once IARC monograph is available. Did the IARC consider community level exposures of PFAS and their association with the cancers?	Noted. The IARC monograph will be reviewed when published and any changes to the fact sheet made as required as advised by the Water Quality Advisory Committee. From limited information in the IARC summary (Zahm et al. 2024), there were inconsistent findings re: cancer associations from studies examining community level exposures of PFOA and PFOS (hence 'limited' or

			'inadequate' evidence for cancer in humans for PFOA and PFOS respectively).
32	Health considerations	The fourth paragraph correctly says that the sites in the ANU study were from heavily contaminated communities. This should be moved to the second paragraph where the ANU study is first introduced. Otherwise, it should be somehow made clear that the sites in the ANU study are not typical of levels found in Australia.	Accepted. Text amended.
33	Health considerations	The following sentence may need clarification as it is unclear what is meant here: In addition, thresholds for the reported associations could not be readily discerned from the data available in the studies (SLR 2024c).	Accepted. Text amended.
34	Health considerations	Re: PFOA section - Was the NTP study peer reviewed? I thought I saw a statement that one of the NTP studies was not peer reviewed. I presume that potential confounders were controlled, if relevant, such any background incidence of cancers in the animals studied. Was that the case?	Noted. Confirming that NTP (2023) study was peer reviewed before publication. The reviewers also evaluated the study for study quality including against confounders and controls/background incidence. It was found that for both males and female rats, the incidence of acinar findings (for which historical control data were provided) in experimental controls were similar to historical controls. A footnote on study quality has been added to the Health considerations section to clarify the meaning of a high-quality study and how it was assessed by the reviewers.

35	Health considerations	Concerns raised with clinical relevance of liver effects observed in NTP (2023) to humans, noting that the toxic and carcinogenic effects on the livers of rats were attributed to the action of PFOA as a PPARα agonist. Lesions in rodents mediated by PPARα agonist activity are not suitable for identifying a human HBGV for PFAS because of the inter-order differences in responses to PPARα agonists. The increase in acinar cell adenomas, with a nonsignificant increase in acinar cell carcinomas, in the NTP study is therefore likely to be attributable to PFOA's action as a PPARα agonist and not relevant to human health risk assessment. PFOA has not been associated with an increased incidence or risk of pancreatic cancer in epidemiological studies (references and further detail provided in submission). The US EPA concluded that the critical effect in the NTP study is hepatocellular necrosis, for which the LOAEL is 20 mg/kg bw/day in male rats. The US EPA does not consider hepatocellular necrosis to be part of the spectrum of hepatic lesions induced by PPARα agonist activity. However, studies in nonhuman primates and in humans do not support the conclusion that hepatocellular necrosis is an adverse effect relevant to human health risk assessment. On the basis of uncertainty, it is not considered that the liver toxicity observed in the NTP study in rats is appropriate for quantitative human health risk assessment.	Partially accepted. Text amended to reflect final choice of guideline option for PFOA after feedback from targeted consultation and advice from the Water Quality Advisory Committee and reviewer. Amendments made to review reports to provide more information/references to clarify clinical relevance of neoplastic pancreatic effects observed with PFOA in the NTP (2023) study. There is high confidence that the hepatic neoplastic lesions are unlikely to be relevant to humans, as this is supported by the human relevancy mode of action analysis conducted by Klaunig et al. (2012). However, with respect to hepatic necrosis (a non-neoplastic effect of PFOA in animal studies), the external independent scientific reviewer of the Addendum report supported the use of non-neoplastic hepatic effects as an appropriate endpoint on which to base a point of departure for PFOA. Although there is uncertainty with respect to the dose at which non-neoplastic hepatic effects may occur in humans and it is recognised by the reviewers that rats are likely more sensitive to this

			effect that humans, the reviewers consider there is insufficient information to rule out human relevancy of this effect at this time.
36	Health considerations	Concerns raised about the human relevancy of the neoplastic acinar pancreatic lesions observed in rats exposed to PFOA and their subsequent use in deriving a candidate guidance value for PFOA.	Partially accepted. Text amended to reflect final choice of guideline option for PFOA after feedback from targeted consultation and advice from the Water Quality Advisory Committee and reviewer. Amendments made to review reports to provide more information/references to clarify clinical relevance of neoplastic pancreatic effects observed with PFOA in the NTP (2023) study.
37	Health considerations	Re: PFOS section - Concerns raised with clinical relevance of thyroid effects observed in NTP (2022) to humans. A number of comments were made regarding endpoint selection with respect to the decreases in thyroid hormone levels, its relevancy to humans, thyroid hormone analysis and the benchmark dose analysis undertaken by the reviewers for thyroid hormone effects.	Accepted. Text amended to reflect final choice of guideline option for PFOS after feedback from targeted consultation and advice from the Water Quality Advisory Committee and reviewer. Review reports amended to clarify clinical relevance of thyroid effects observed in NTP (2022).
38	Health considerations	Re: Developmental study in mice (Zhong et al. 2016) It has previously determined that immunomodulation is not suitable as a critical endpoint for quantitative risk assessment for PFAS. While	Noted. No changes made. While previous reviews have determined that immunomodulation is unsuitable, the current

		PFOS can adversely modulate immune system responsiveness (Drew and Hagan 2016), there are significant uncertainties regarding species sensitivity, strain sensitivity and the influence of route of administration on immune system modulation by PFOS that are yet to be resolved. As a result, it has not been possible to determine a reliable NOAEL or LOAEL for adverse effects on immune function for use in a quantitative risk assessment of PFOS.	review is tasked with determining if this may be different now in light of more recent studies. In 2016, the opinion was that immunomodulation can be used for hazard identification, but not really dose response, assessment, at the time. It is a standard expectation that as more data become available, this conclusion may need to be revisited. It is also noted the Zhong et al. (2016) study was not reviewed / included in the Drew and Hagen (2016) review.
39	Health considerations	Re: selection of a 28-day toxicity study in rats (NTP 2022) to establish a tolerable daily intake for PFOS. • The use of a 28-day oral gavage study to establish a TDI is unusual in chemical risk assessment and has not been justified by SLR Consulting. • Typically, acceptable short-term studies need to be at least 3 months in duration to be considered suitable for use in the establishment of a TDI (IPCS, 2020). • It is noted that long-term and reproductive/developmental studies are available for PFOS and considers these to be more appropriate for establishing a TDI.	Partially accepted. It is not unusual for this to occur if the study is considered to be a high-quality study. However, it can be more unusual where chronic studies are available. Amendments made to the Addendum Report to refer to the effects on thyroid hormone (or lack thereof) in other chronic studies with PFOS.
40	Health considerations	Re: PFBS section - Are there concerns about the limitations of the NTP study? The NTP study was considered as the best study for some other PFAS but here Feng was considered to be the best	Accepted. Text amended in Health Considerations and Guideline Derivation sections to highlight concerns about

		available. If NTP is not peer reviewed, are there any other studies that replicated the results of NTP? I presume that these questions have already been considered in NHMRC expert review (and apologies if I have missed this).	observed effects in the NTP (2022) study for PFBS and rationale for choice of Feng et al. (2017) as the key study for deriving a health-based guideline value for drinking water. The Evidence Evaluation Report concluded that any of the values in the range of 1,050 to 2,100 ng/L would be sufficiently health protective for PFBS, noting that 2,940 ng/L was derived using the rat toxicology study from NTP (2022) and values ranging from 1,050 to 2,100 ng/L were derived using the mouse toxicology study by Feng et al. (2017). It did not conclude that either study was more appropriate for derivation. The reviewers evaluated the NTP (2022) study for study quality including against confounders and controls/background incidence and found that the NTP (2022) study was high quality. The NTP (2022) study was peer reviewed (details of peer reviewers provided in the report). Both studies (NTP (2022) and Feng et al. (2017) were considered high quality by the reviewers.
41	Guideline derivations	Is the relative contribution of drinking water to daily intake known? May be useful in Q&A	Accepted. Information on estimates for relative contribution added to general

			description section and included in Q&A resource.
42	Guideline derivations	For consistency with other ADWG factsheets, and to avoid confusion about what a mathematically "correct" GV should be, the dot points detailing the rounding of each GV and the reference to chapter 6 should be removed. We don't want people thinking, for example, that PFBS should be 1,120 ng/L.	Noted but no changes made. Committee advised to include information on rounding convention to show where the final number came from, consistent with more recent fact sheets.
43	Guideline derivations	• The NTP (2019) was chosen as the critical study for setting PFOS guidance values (2024c page 54). • Critical effect chosen was *large decreases in T4 and free T4, but with no accompanied histopathological changes of thyroid- gland or any change in TSH*. • *Serum total thyroxine (T4) and free T4 were significantly (p < 0.05) reduced (by ≥ 62% for* *total T4 and free T4 in males cf. control; by ≥ 50% for total T4 and by ≥ 39% for free T4 in* *females cf. control) at all dose levels. Significantly (p < 0.05) reduced (≥ 31% in males cf.* *control and ≥ 19% cf. control in females) serum triiodothyronine (T3) occurred at ≥ 0.625* *mg/kg bw/day. While these effects were not accompanied by any significant (p < 0.05)*	Accepted. Text amended to reflect final choice of guideline option for PFOS after feedback from targeted consultation and advice from the Water Quality Advisory Committee and reviewer. Review reports amended to clarify clinical relevance of thyroid effects observed in NTP (2022).

		change in serum thyroid stimulating hormone (TSH) concentrations or microscopic anatomic *changes in the thyroid glands, they are regarded as being adverse due to the magnitude of* *the changes in serum T3 and T4 levels. (2024C page 37).* • No rationale has been provided in terms of why NHMRC has chosen this as a critical effect. • ***What does this reduction in T4 and free T4 mean without changes in TSH levels and histopathology of thyroid gland in human context and how critical is it for human health? Does this lead to hypothyroidism in humans? It would be good to get some advice from a clinical toxicologist.***	
44	Guideline derivations	I note that SLR conducted the independent expert evidence evaluation. Could the fact sheet include reference to the SLR assessment 'A review of existing guidance and guidelines (SLR 2024a, b) found that the current Australian guidance value for PFOS of 20 ng/kg/day and guideline value of 70 ng/L are still considered health protective.'	Partially accepted. Text amended to reflect final choice of guideline option for PFOS following feedback from targeted consultation and advice from the reviewers and the Water Quality Advisory Committee. Reports amended to clarify the different guideline options that were suitable for adopting/adapting for consideration by the Committee.

45	Guideline derivations	• SLR Evaluation report (SLR 2024b) recommends retaining the current drinking water guideline for PFOS – i.e. 70 ng/L. (Section 6.3 page 52-53 SLR 2024b) • Report was published in February 2024 (SLR 2024b). • This report appears to have been accepted by the NHMRC as completed in terms of normal report review procedures. • This report does not discuss the NTP report in relation to PFOS and does not use the results from that study as the basis for the guideline. • The Feb 2024 report appears to have evaluated the information about PFOS appropriately and to follow the normal guidance for drinking water guideline calculation – ***it is not clear why additional work was required***. • August report (SLR 2024c) indicates NHMRC asked for additional work subsequent to US EPA updating its DWGs (April 2024). • August report only looked at 2 additional experimental animal studies (see Section 5.3 page 52-55 (SLR 2024c)). One of the additional studies was the draft of the NTP study from 2019 (i.e. NTP 2019 – page 54). A final version of the report for this study was published in 2022 (NTP 2022). NTP 2022 was used in the Feb report (SLR 2024b, page 58-59) to provide data to calculate the PFHxS guidance values for guideline. ***It is not clear why an earlier***	Noted. The reviewers undertook an initial review of existing guidance/guidelines that was finalised in February 2024 (SLR 2024a, b). The NTP (2022) report was not discussed in these review reports because it was not used as a key study by other international assessments to derive a guideline value for PFOS at that time and was therefore not included for discussion. When the US EPA published their final advice for PFOS in April 2024, the final assessment report included a new basis for their drinking water guideline value and the Water Quality Advisory Committee advised that this should be considered as part of the PFAS fact sheet review. This included a review of several human and animal studies that had been considered by the US EPA in their final PFOS assessment. This time, the NTP (2022) study had been considered by the US EPA as a candidate study in deriving a reference dose for PFOS and was therefore included and discussed in the Addendum report. It was presented as a potential guideline option as it was considered a high-quality study and suitable to adopt/adapt (SLR 2024c).

		draft would now be considered for PFOS, not the final version from 2022. It is a standard practise to use the latest version for scientific rigor.	Review reports updated to make citations consistent, and footnote added to section 5.2 of Addendum Report. NTP (2019) and NTP (2022) are the same study and both citations have been used in SLR (2024 a, b, c) depending on each guidance/guideline document under review. The NTP (2019) report has been revised since initial publication and updated in 2022 (NTP 2022). The most current version of the report (NTP 2022) was the only version considered by the reviewers during the review process, regardless of how it was cited in the reports.
46	Guideline derivations	• In both sections, the report states that 70 ng/L is still health protective, but not sure why NHMRC picked 4ng/L as the best candidate value. • Last paragraph in Section 5.3 (on page 57 of report (SLR 2024c)) discusses the practicality of applying a guideline of 4 ng/L. • This discussion includes that currently Australian drinking water mostly contains up to 6 ng/L and at times up to 16 ng/L • They indicate these existing levels essentially comply with the 4 ng/L value because of the source contribution term (relative source contribution) – i.e. because the guideline	Accepted. Text in draft fact sheet amended to clarify selection of final guideline option for PFOS following feedback from targeted consultation and advice from the reviewers and the Water Quality Advisory Committee. The review reports presented different guideline options that were suitable for adopting/adapting for consideration by the Committee. The Committee have considered the options for deriving a guideline value based on what they consider the most critical health effect from the best available evidence.

		only allows drinking water to take up 10% of the TDI even if the concentrations are slightly above the guideline this will not result in health effects. • *While this is true, that's not how DWGs are applied.* • *Water utilities are required to provide drinking water that complies with the guidelines and if they can't do that then they cannot provide drinking water – which has way more health effects than a little bit of PFOS.* • This discussion also includes information that areas near to heavily contaminated areas will be likely to not comply with this guideline.	
47	Guideline derivations	• PFOS discussion in fact sheet lists NTP 2022 report as source for Point of Departure (POD) and the use of an uncertainty factor of 300 (combined) (page 11 – draft fact sheet). • Toxicokinetics has been assessed using PBPK modelling to convert from a serum concentration in rats to a serum concentration in people (i.e. human equivalent dose). *There is insufficient information here to work out if this has been done correctly.*	Noted. Details provided in the review reports. Toxicokinetic adjustment was undertaken by applying a PFOS clearance factor of 0.000128 L/kg-day and a PFHxS clearance factor of 0.00009 L/kg-day to the PFOS and PFHxS, respectively, serum points of departure to derive a human equivalent dose point of departure.
48	Guideline derivations	Concerns about use of uncertainty factors for derivation of the candidate guidance values for PFOS and PFHxS based on a 28-day study (e.g. the application of an additional 10-fold uncertainty	Noted but not changes made. Although some information on the choice of uncertainty factor is provided by enHealth (2012, pg. 71), professional judgement is required. The

		factor for the use of a short-term study when long-term studies and reproductive/development studies are available)	reviewers considered the uncertainties and concluded a similar total uncertainty factor of 300 would be warranted for PFOS (and PFHxS) for use of an endpoint from the 28-day NTP study.
49	Guideline derivation	Will have a closer look at SLR report to better understand derivation of this uncertainty factor, particularly in relation to a short-term study. Is there a standard reference for this uncertainty factor? • The combined uncertainty factor is made up of 3 for animal to human extrapolation (toxicodynamics); 10 for human variability and 10 to address the fact that the NTP study was short term (28 days). • This same NTP study was used to calculate the guideline for PFHxS. • A combined uncertainty factor of 300 was also applied to the POD for PFHxS, however, it was based on 3 for animal to human extrapolation (toxicodynamics); 10 for human variability and 10 for a limited database. ***Either a factor of 10 to address short term issues should have been applied to both or to neither of them. It makes no sense to apply it to one and not the other as both PFOS and PFHxS are similar chemicals.***	Not accepted. SLR (2024a,b) justified the omission of an uncertainty factor (UF) for a sub-chronic study in the guideline derivation for PFHxS as it was considered suitably covered by the UF of 10 for a limited database (including lack of chronic studies). This decision was also considered against the balance of having an unnecessarily high UF of 3000 and the conclusion by the reviewers that 300 would be suitably health protective for PFHxS.

50	Guideline derivations	I note that SLR conducted the independent expert evidence evaluation. Could the fact sheet include reference to the SLR assessment that 'the existing 70 ng/L guideline value for PFOS+PFHxS are considered to be sufficiently health protective'? I am not certain whether/how this should be qualified by statement in the 'evidence to decision' document 'It is uncertain that this value will continue to be protective of health for PFHxS in light of the NTP (2022) study which was not available to FSANZ when considering the derivation of a guideline value for PFHxS.'	Noted. Text amended to reflect choice in final guideline options following feedback from targeted consultation and advice from the reviewers and the Water Quality Advisory Committee. Reports amended to clarify the different guideline options that were suitable for adopting/adapting for consideration by the Committee.

#	Feedback received	Action/Response
General comments (draft Review Summary, revised as NHMRC Statement):		
51	Re: defined scope and limited resources. I'm not sure this sentence is necessary. I think the following sentences explain the focus on the selected PFAS.	Accepted. Text amended to clarify.
52	Would suggest including a little more on why others haven't been included - make it clear they have not been detected/are unlikely to be present, only limited information exists, etc.	Accepted. Text amended to clarify.
53	Re: rolling revision of the Guidelines as evidence and resources become available. I wonder whether the question of resources is one for the NHMRC and Government(s) rather than for the public statement.	Accepted. Text amended.

54	Should it be made clear that exposure from drinking water for a non-exposed community have been estimated to be ~3% of total PFAS exposure (Thompson et al. 2011)	Accepted. Sentence added, with reference list created with Thompson 2011 reference included.
55	Re: estimation of approximately 2-3% of total PFAS exposure. Is this used for the derivation or 10% ? Need to clarify for the Q&A as it says 10% more conservative than 20%, but also mentions 2%.	Accepted. Q&A amended to clarify relative source contribution used in guideline derivation.
56	Consider emphasising this sentence: It is not uncommon for international agencies to differ in the way that they calculate guideline levels and manage risks from chemicals	Noted but no changes made. This point is also addressed in the FAQs, can consider other methods of emphasis if available to NHMRC at final publication.
57	'The health-based guideline values in the Guidelines represent the concentration of a chemical in drinking water that does not result in any significant risk to health of the consumer over a lifetime of consumption.' I note that SLR conducted the independent expert evidence evaluation. Could the fact sheet include reference to the SLR assessment that 'the existing 70 ng/L guideline value for PFOS+PFHxS are considered to be sufficiently health protective'? Could this summary, the fact sheet and Q+A acknowledge this?	Noted. Text amended to reflect choice in final guideline options following feedback from targeted consultation and advice from the reviewers and the Water Quality Advisory Committee. Review reports amended to clarify the different guideline options that were suitable for adopting/adapting for consideration by the Committee.
58	Consider elaborating a bit further as to why, for this sentence: *NHMRC did not consider the available studies in humans to be sufficiently reliable or appropriate to derive Australian health-based guideline values for drinking water*	Accepted. Sentence added about limitations of studies.

59	'It is expected that it will take time and resources to implement the new PFAS health-based guideline values in Australia…' Can this be acknowledged in the Q&As/guidelines also?	Accepted. Has been acknowledged in Q&As.
60	'…providing 3 years for monitoring requirements and 5 years…' add to take action to reduce elevated levels of PFAS I've suggested an edit. NHMRC may have a better edit here. US EPA states: • Public water systems must monitor for these PFAS and have three years to complete initial monitoring (by 2027), followed by ongoing compliance monitoring. Water systems must also provide the public with information on the levels of these PFAS in their drinking water beginning in 2027. • Public water systems have five years (by 2029) to implement solutions that reduce these PFAS if monitoring shows that drinking water levels exceed these MCLs. • Beginning in five years (2029), public water systems that have PFAS in drinking water which violates one or more of these MCLs must take action to reduce levels of these PFAS in their drinking water and must provide notification to the public of the violation.	Accepted. Text amended. Additional information included in Q&As.
61	Might be worth pointing to monitoring responsibilities here, state/territory vs cth., etc	Accepted. Sentence added to point to monitoring responsibilities.

#	Relevant section	Feedback received	Action/Response
General comments (Evidence to Decision tables):			

62	PFOA Exposure profile	Recommend noting that the current sampling across Australia (including that of drinking water utilities) has found detections in water sources without high-risk sources. This will help to highlight the ubiquitous nature of PFAS in environmental waters. Added: However, it is noted that low concentrations of PFAS have been detected in water supplies not impacted by contaminated sites.	Accepted. Text amended and actioned across other EtD tables where relevant.
63	PFOA Feasibility	For some localities there may be no other option than to use a source water with levels below the guideline value, or a shandy of water sources to ensure the guideline values is met. Suggested edits made to text.	Accepted. Text amended and actioned across other EtD tables where relevant.
64	PFOA Resource impacts	Added: Through various reporting obligations water utilities may need to report these exceedances publicly. In some cases, a new water source may need to be developed to meet guideline values.	Accepted. Text amended and actioned across other EtD tables where relevant.
65	PFOS Page 4, under 'Values and preferences' section, second last paragraph	"It is likely that consumers and communities (particularly those affected by PFAS contamination) will continue to be risk-averse to the effects of exposure to PFOS. While the findings of the NHMRC review should reassure the public that the health evidence has been considered and why a particular guideline value was chosen, there is likely to be ongoing concern from some groups that Australian advice doesn't align with other international agencies that have adopted more conservative guideline values or used different critical health endpoints, despite the SLR (2024a, b, c) review finding several issues with the evidence base for these approaches." This is not relevant if the 4 ng/L value is adopted and seems to be pasted from PFOA fact sheet (Attachment C).	Partially accepted. Amended paragraph, as some of this information is still relevant as the Values and Preferences section covers guideline value options from 70 to 4 ng/L (not just the lowest option) to demonstrate why some of these options might not be acceptable to consumers.

66	PFOS Page 4, under 'Values and preferences' section, last paragraph	"Clear and consistent public health messaging and risk communication, including explanations about the differences between international jurisdictions, guideline value derivations and the NHMRC review process, could help." It certainly could help but where is this sentence / statement going?	Accepted. Text added to clarify.
67	PFHxS Health evidence profile	I note that SLR conducted the independent expert evidence evaluation. Could the fact sheet include reference to the SLR assessment that 'the existing 70 ng/L guideline value for PFOS+PFHxS are considered to be sufficiently health protective'? I am not certain whether/how this should be qualified by statement in the 'evidence to decision' document 'It is uncertain that this value will continue to be protective of health for PFHxS in light of the NTP (2022) study which was not available to FSANZ when considering the derivation of a guideline value for PFHxS.'	Noted. Text amended to reflect changes to Review Reports to clarify the different guideline options that were suitable for adopting/adapting for consideration by the Committee.
68	PFHxS Exposure profile	'However, there are many sites of PFAS contamination in Australia, and, if water from these contaminated sites is used as a local source of drinking water (e.g. backyard bore in rural location where distributed water is not available), PFHxS may be present at concentrations greater than the candidate health-based guideline value and the existing Australian health-based guideline value in these cases'. Is this statement specific to PFHxS, or can it apply to other species?	Noted. Statement specific to PFHxS and reference added to review report.
69	PFBS	The concerns for feasibility under options 2-5 ("However, the guideline options may not be achievable for local drinking water supplies in contaminated areas without addition of a PFAS-removal treatment step or use of an alternative	Accepted. Text amended.

	Page 4, Feasibility	water supply.") seem to be inconsistent with the exposure profile information earlier on in the table, page 2. Certainly, in Queensland, detections of PFBS in drinking water sources and drinking water is rare and levels are in the low ng/L range at most.	

Appendix C – Expert Review feedback on draft guidance

Expert review was undertaken on the draft guidance between 13 September to 9 October 2024.

As part of the consultation, NHMRC sought specific feedback on the following:

1. Please comment on the appropriateness of the guidance (Fact Sheet) in regard to its readability and usefulness, given the target audience of the *Australian Drinking Water Guidelines*, e.g. is the draft Fact Sheet relevant, accurate and easy to understand?
2. Do you support the approaches taken to review the evidence and derive the health-based guideline values? e.g.
    - whether appropriate evidence has been identified and reviewed, and if any evidence has been missed, given the scope and review approach of this fact sheet update (as outlined in the Research Protocol)
    - whether the evidence has been appropriately considered, interpreted and translated, using the Evidence-to-Decision Framework for each PFAS chemical to derive the health-based guideline values in the draft Fact Sheet?
3. General/overall comments on the draft Fact sheet and supporting information

Additional feedback was sought from the Expert Reviewer in early October on the corrected review reports and the table of targeted consultation comments and how these had been addressed by NHMRC and/or the reviewer.

Expert reviewer: Adjunct Professor Brian Priestly
<u>Feedback received for Question 1:</u> Please comment on the appropriateness of the guidance (Fact Sheet) in regard to its readability and usefulness, given the target audience of the Australian Drinking Water Guidelines, e.g. is the draft Fact Sheet relevant, accurate and easy to understand?
The draft Fact Sheet follows a standardised approach in outlining some general information about potential sources of PFAS exposure, occurrences in Australian drinking water sources and measurement issues, approaches to drinking water treatments, and a detailed summary of potential health effects, leading to the derivation of new health-based guideline values (HBGVs) for PFOA, PFOS, PFHxS and PFBS, but not for GenX chemicals. The readability of the Fact Sheet is good, the text is well referenced, supporting data are adequate and it should be useful to the target audience of the ADWG. There is a strong emphasis on evaluating the quality of the studies reviewed, using a standardised evaluation process (Appendix B). Studies selected for derivation of guideline values were generally rated as providing 'high confidence'. It is noted that the draft Fact Sheet was developed using an iterative process between SLR (the Consultants) and the NHMRC Water Quality Advisory Committee over the period October 2022

to August 2024 and that several key studies were newly published during this time (including new US EPA water advisories in April 2024). It is noted that these iterative processes were thorough and that new studies were appropriately addressed in revisions of the draft Fact Sheet.

Feedback received for Question 2:

Do you support the approaches taken to review the evidence and derive the health-based guideline values? e.g.

- whether appropriate evidence has been identified and reviewed, and if any evidence has been missed, given the scope and review approach of this fact sheet update (as outlined in the Research Protocol)
- whether the evidence has been appropriately considered, interpreted and translated, using the Evidence-to-Decision Framework for each PFAS chemical to derive the health-based guideline values in the draft Fact Sheet?

The evidence reviewed by SLR and the NHMRC WQAC [Water Quality Advisory Committee] is extensively covered, with sufficient detail and analysis to provide confidence that the most appropriate studies, toxicological endpoints and methodologies for assessing new water quality guideline values have been used. It is noted that the consensus was to reject the approach used by some international authorities to use either immunomodulation endpoints or changes in lipid homeostasis drawn from human epidemiological studies, rather than controlled-exposure studies in animals. I completely agree with that conclusion and I will elaborate further in Section 3 of this report.

It is useful that the three SLR reports (Feb 2024 and Addendum Aug 2024) and the NHMRC Draft Evidence to Decision tables summarise the different options for selecting Point of Departure (POD), Human Equivalent Dose (HED calculation and selection of Uncertainty Factors (UF), leading to different values for water guideline values under consideration. Note that the Draft Evidence to Decision table for PFHxS needs to be extensively re-written, since it makes several references to maintaining the PFOS HBGV at 70ng/L and was presumably drafted prior to the August 2024 re-consideration of the PFOS HBGV.

The provision of cogent reasons for the adoption or rejection of these options assists with understanding the final proposals and the confidence attached to them. However, outlining all the options does provide a basis for exploring different values from the ones recommended, should the public consultation phase suggest more suitable values or question the validity of the proposed numbers.

My view is that the new proposed numbers for PFOA, PFOS, PFHxS and PFBS are well supported, appropriately conservative, and provide adequate health protection for Australian consumers of potable water.

It is noted that, unlike Toxicity Reference Values (TRVs) developed in other jurisdictions, the critical toxicological endpoint that emerges for PFOS, PFHxS and PFBS in the SLR reports is essentially the same (modification of thyroid hormone status), possibly leading to other health effects (e.g. developmental toxicity). That seems to make biological sense and is reinforced by

some observed associations between PFAS exposure and thyroid hormone status seen in some human epidemiological studies (see also Ballesteros *et al* 2017, Boesen *et al* 2020, Coperchini *et al* 2021). It is not entirely clear how the different Benchmark doses (BMD) used for POD were calculated from the study data, but it appears that SLR essentially relied on values calculated by the US EPA in the case of PFOS, or by NTP, OEHHA for PFHxS and PFBS.

I have some reservations about the choice of a carcinogenicity endpoint for PFOA (pancreatic acinar adenomas and adenocarcinomas), rather than non-neoplastic hepatic, developmental or immunological endpoints, because the epidemiological evidence is more strongly suggestive of only renal and testicular carcinogenesis in humans (Bartell & Vieira 2021, Steenland & Winquist 2021), rather than tumours at these sites in rodents. This could be complicated by the differences between rodents and humans in sensitivity to agents acting on the PPARα receptor systems. This is not a crucial point, because the US EPA evaluation on which the SLR report is based, confirms that "….. *site concordance is not always assumed between humans and animal models*." However, I do support the use of a threshold approach to TRV development for PFOA from a cancer endpoint, since the evidence for PFAS genotoxicity is insufficient to support a non-threshold approach.

PFAS appear to share some key characteristics of carcinogens other than genotoxicity, such as acting on receptors, through epigenetic mechanisms or inducing cellular proliferation (Temkin *et al* 2020). Furthermore, the human epidemiological data on PFAS-related cancer remains patchy. A study of a Swedish cohort (Li *et al* 2022) tends to confirm a link between kidney cancer and PFOA exposure, but it found no associations with PFOS or PFHxS, the other two PFAS for which water quality guidelines have been developed. On the other hand, findings of an increased risk of kidney cancer associated with serum PFNA, with some odd ethnic differences, suggest that this cancer site may be a PFAS class effect (Rhee *et al* 2023). Evidence that testicular cancer may be associated with PFOS as well as PFOA is suggested by findings in U.S. Service personnel exposed to fire-fighting foams, although the findings were positive in only one of two sampling times, and no associations were found with PFOA or PFHxS (also elevated in these serum samples), with an inverse association with PFNA (Purdue *et al*, 2023).

The crucial carcinogenic endpoint chosen by the US NTP and by SLR was an increase in pancreatic acinar cell adenomas in males (all doses) and to a lesser extent in females. The methodology used by the US EPA to derive the BMD_{10} for this endpoint is not well detailed and given that the incidences in all dose groups were mostly less than 10% in females and 40-60% in males, with quite flat dose-response relationships and no clear NOAEL, it must have been difficult to determine, with any precision, the BMD_{10} used as the POD for risk analysis. While I am unable to find any evidence that a BMD_{10} was calculated by NTP or the US EPA for non-neoplastic effects in the liver and pancreas, inspection of the data suggests that such a BMD_{10} would not be materially different from that calculated for cancer incidence. Therefore, it probably makes little difference whether the neoplastic or non-neoplastic effects drive the risk assessment for the development of water quality guidelines.

The only other 2yr rat study for PFOA (Butenhoff *et al* 2012 – admittedly a study of lower quality according to NHMRC criteria) found some evidence of Leydig cell testicular tumours in male rats, but failed to find any evidence of pancreatic tumours or hepatocellular carcinomas

(typically found with agents acting on PPARα receptors) while noting non-neoplastic lesions in several organs, including evidence of liver damage.

I agree with SLR preference for using the better quality NTP 2yr rat study rather than Butenhoff, to develop new HBGVs for PFOA.

Feedback received for Question 3:

General/overall comments on the draft Fact sheet and supporting information

The derivation of a water quality guideline is essentially a four-stage process and it is well described and used in the SLR reports:

1. The first step is to derive a Toxicity Reference Value (TRV), based on an appropriately identified toxicological end point, along with relevant quantitative dose-response relationships. The toxicological end point should be the most sensitive (i.e. occurring at the lowest levels of exposure) among the several potential health effects, be considered relevant to extrapolation to predict human health outcomes, and be associated with a relevant period of exposure (for public health community exposures, this is assumed to be continuous exposure over a lifetime; for occupational exposures, the time period can be shorter).
2. The dose-response relationship is examined to determine an appropriate point-of-departure (POD) for TRV derivation. In most cases, this is an estimated No-Observable-Adverse-Effect-Level (NOAEL) from controlled exposure studies in animals. Even the definition of the NOAEL is itself is subject to qualitative interpretation, along with the experimental design, most notably the choice and spread of the doses administered. Alternatively, the POD may be a Benchmark Dose derived from an analysis of the full dose-response data set, and estimating the dose or exposure associated with a defined level of risk (e.g. BMD_{10}).
3. Various adjustments are made to the estimated NOAEL or BMD to determine a human equivalent dose (HED) and apply one or more Uncertainty Factors (UFs) to manage potential inter- and intra-species variability in response. In the case of PFAS, derivation of the HED using toxicokinetic adjustments is required to account for the significant differences in clearance kinetics across species
4. A health-base guideline value (HBGV) for good water quality is then developed using a standard formula that takes into consideration the TRV, a factor (usually 10%) that accounts for the proportion of total intake that may be attributed to drinking water, as opposed to all other potential sources, and an estimate of the average drinking water daily intake (conventionally 2 L/day for adults).

The selection of the UFs for the four PFAS is worthy of further comment, since they make a substantial contribution to the extent of conservatism in the proposed values.

In the case of PFOA, the UF is 30x, incorporating 3x for uncertainty in extrapolating from animals to humans and 10x to account for variability in exposed human populations. The 3x factor (as opposed to the more conventional 10x), is justifiable on the basis that the uncertainty

in extrapolation is reduced by comparing serum levels across species at which NOAELs or BMDs. Theoretically, it could be reduced further to 1x, which would result in a three-fold higher HBGV.

In the case of the other PFAS, the UF is tenfold greater (300x), comprising the above 3x and 10x factors, with an additional 10x factor to account for deficiencies in the available toxicity database (PFHxS and PFBS) or, for PFOS, an exposure period shorter than a conventional lifetime study (as was used for PFOA, where no additional 10x was required). Since the studies used for PFHxS and PFBS were also shorter than lifetime, the argument for using the same 10x UF is a little convoluted. It could be argued that the additional 10x UF is not required (or a value lower than 10x could be used) since the toxicological endpoint (thyroid hormone modulation) might not depend so much on the duration of exposure.

An interesting argument advanced by Perez *et al* (2023) is that application of the 10x factor for variability in exposed populations may be superfluous where the study group used (children's response to vaccination, as used in the 2022 US EPA water quality derivation) already represents responses in a most sensitive sub-population. This point is not so relevant for the toxicological endpoints chosen by SLR in their PFAS HBGV derivation, as they are not likely to be age- or gender-specific.

The overall outcome is that the HBGVs proposed by SLR and NHMRC in this report are possibly overly conservative, although they would provide some additional margin of safety between the HBGV and expected exposures to PFAS from most potable water sources in Australia.

Why immunomodulatory responses were rejected as a valid toxicological endpoint

Worthy of further comment is the rationale for rejecting the immunomodulation response used for TRV development by EFSA, the USEPA and some other agencies. The SLR analysis is consistent with that taken by FSANZ following its review of the PFOA and PFOS/PFHxS TRVs in 2017, with SLR incorporating some new studies published since the FSANZ review.

I agree with the SLR and FSANZ positions regarding immunomodulatory responses and this is further reinforced for me by some other critical studies that have not been cited by either FSANZ or SLR. These include a reviews that critically evaluates the weaknesses of the approach taken by the US EPA in its 2022 interim drinking water guideline development (Perez *et al* 2023), or reach a similar conclusion about the suitability of an immunomodulation endpoint for HBGV derivation, such as:

- "…. *Panel members agreed that the Faroe Islands cohort should not be used as the primary basis for deriving PFAS risk assessment values. The panel agreed that vaccine antibody titre is not useful as a stand-alone metric for risk assessment*" (Garvey *et al* 2023),
- an overview of the current state of animal and human studies on immunomodulation, with the conclusion "….. *The limitations of the current database on associations of human PFAS exposures outlined here indicate that more evidence is required to select immunomodulation as a critical endpoint for human PFAS risk assessment*" (Antoniou *et al* 2022)

- a criticism of the new, very low USEPA drinking water health advisories for PFOA and PFOS, that includes the statement "…. *The Grandjean et al (2012) and Budtz-Jorgensen & Grandjean (2018) studies are a thin basis, considering current PFAS levels of PFAS in U.S. drinking water*" (Cotruvo *et al* 2023)
- Another recent review of the possible effects of PFAS on vaccine responses that reached the conclusion "….. *Epidemiological data on immunosuppression and five principal PFAS suggest an association, with support across antibodies against multiple types of antigens. Data on Diphtheria, Rubella and tetanus were more positive of an association than for other antibodies, and support was greater for association with PFOA, PFOS and PFHxS, than for PFNA or PFDA. The data on any specific antibody were scarce. Confounding factors that might account for the relation were not identified. Nearly all studies evaluated were judged to have a low or moderate risk of bias*." (Crawford *et al* 2023).

Some studies that further illustrate the inconsistencies in PFAS-related immune responses or outcomes reflective of immune responsiveness are:

- Findings of some inconsistent, but apparently gender-specific associations between some PFAS (e.g. PFUnDA) and asthma or eczema in children following maternal exposures (Impinen *et al* 2018, 2019)
- Variable associations of several PFAS with eczema and atopy in children at 1 year of age, with an apparent protective effect of PFUnDA (Lowe *et al* 2019)
- No associations between PFOS serum concentrations and immune phenotypes or incidence of multiple sclerosis (Ammitzboll et al 2019)
- Variable effects on childhood allergies and infectious diseases at ages 4 and 7 years in a cohort of Japanese children (Bamai *et al* (2020, Atagi *et al* 2024).
- Variable effects on childhood asthma and infectious diseases at age 10 years in a cohort of Norwegian children, with possible gender-related differences in sensitivity (Kvalem *et al* (2020)
- A small positive association between PFOS exposure and upper and lower respiratory tract infections but less so with PFOA, and no association with PFHxS or PFDA in a cohort of Danish children (Dalsager *et al* 2021)
- Relatively small effects on total lymphocyte counts with PFHxS (but less so with PFOA and PFOS) in a cohort of adults in the Mid-Ohio valley (C8 study) (Lopez-Espinosa *et al* 2021)
- No effect on Covid-19 vaccine antibody response in an adult cohort from a heavily contaminated area of Sweden (Ronneby) (Andersson *et al* 2023). Similar results were found in an adult cohort of retired former workers from 3M in the USA (Porter *et al* 2022), with Starling (2023) commenting that these results may be indicative of age-related differences in vaccine responsivity or susceptibility to response modification. In contrast, there have been reports of elevated urinary levels of PFOA and total PFAS associated with higher odds ratios for COVID-19 infections in a small Chinese cohort (Ji

et al 2021) and an increase in COVID-19 disease severity associated with serum PFBS (but not for PFOA, PFOS or PFHxS) (Grandjean *et al* (2020).

These and other studies were reviewed by von Holst *et al* (2021) with the conclusion that further investigations are necessary to understand any possible PFAS effects. It is also possible that children are more susceptible than adults, with more positive findings on antibody response to vaccination and mostly negative findings in adult cohorts.

The mechanisms by which PFAS may have immunotoxic effects have been reviewed by Liang *et al* (2022). Earlier studies in mice suggested a role for interaction with PPARα receptors, or specific targeting of T- and B-cell immune responses (DeWitt *et al* 2016). It has been noted that immunotoxicity associated with POPs such as TCDD are mediated by interaction with the AhR receptor complexes and that this can involve epigenetic effects on DNA methylation (Pascual 2021). While there is no direct evidence of PFAS interaction with AhR receptors, it has been suggested that epigenetic effects associated with PFAS include altered DNA methylation, histone modification and microRNA expression (Kim *et al* 2021).

An overall conclusion I would draw is that we appear to be a long way from fully understanding the mechanisms of interaction between PFAS and the immune system and their relevance to human populations.

Toxicokinetic adjustments

Adjustment of NOAEL or BMD doses from animal studies to determine a HED relies on reliable estimates of PFAS toxicokinetic parameters and the selection of appropriate toxicokinetic models. This has been recognised, and appropriately applied, in the SLR and US EPA analyses. Elimination half-life ($t_{1/2}$) or clearance and volume of distribution (Vd) are key toxicokinetic parameters applied to these adjustments. However, published values for these parameters have been quite variable, and much less data are available for some PFAS.

The SLR reports cite Burgoon *et al* (2023) as a recent example of an attempt by an international collaboration (including some Australian scientists) to resolve the variability in TRVs based on differences in studies, toxicological endpoints, extrapolation approaches and application of UFs. However, Burgoon *et al* (2023) selected only one measure of PFOA clearance ($t_{1/2}$ range 2.2 – 2.6 years; mean clearance 0.094 ml/d/kg from Zhang *et al* 2013). This value is consistent with a recently published estimate (2.36 years males, 2.04 years female) based on a young cohort from a contaminated area of Italy (Veneto) (Batzella *et al* 2023). Perez *et al* (2023) and Dong *et al* (2017) have also pointed out the importance of selecting an appropriate $t_{1/2}$ for toxicokinetic dose adjustment. Rosato *et al* (2024) has summarised some of the variability in estimates of toxicokinetic parameters for PFOS, PFOA and PFHxS from human studies.

This point is amplified by comments in the SLR Report derivation of the HED for PFBS, where the choice of toxicokinetic parameters in the Feng study (preferred) and the US NTP study would have resulted in a tenfold difference in the calculated HBGV.

A further point of caution is that toxicokinetic parameters based on individual PFAS may be complicated by differences between isomers. For example, the average $t_{1/2}$ for PFOS and its isomers ranged from 4.0 to 7.5 years, with the longest estimate at 11.5 years (Nilsson *et al* 2022).

Another use of toxicokinetic analysis is to make forward predictions of likely steady-state PFAS serum concentrations associated with intakes of drinking water containing different PFAS levels. These approaches could use a US ATSDR-derived 'tool' (Seltenrich 2023), or a suite of one-compartment models (Lynch *et al* 2023) or Bayesian estimates of relevant toxicokinetic factors based on drinking water intakes (Chiu *et al* 2022). For example, Bogdan *et al* (2023) estimated serum PFOA concentrations associated with different levels of water intake and varying PFOA drinking water concentration. The predicted serum values for drinking water at 100ng/L (half the SLR-proposed PFOA HBGV of 200 ng/L) are 6.07 ng/mL (at mean U.S. water intake 0.017 L/Kg/d) and 15.71 ng/mL (at 95th percentile water intake of 0.044 L/kg/d), with total PFOA serum levels of 7.54 and 17.18 ng/mL taking into account other dietary sources and estimating the contribution of water to total intake at 81% and 91% respectively. These values are orders of magnitude lower than the plasma PFOA concentrations from the NTP study used by SLR to derive the PFOA HBGV (78,000 to 160,000 ng/mL) and the plasma PFOA concentration of 26,900 ng/mL calculated by the US EPA at the BMD_{10} dose level used as the POD for risk assessment.

Supplemental review on later version of draft Fact Sheet:

Further review was sought on the following documents:

- SLR report "Addendum to PFAS evidence evaluation for Australian Drinking Water Guidelines chemical fact sheet (amended 3 October 2024)
- SLR report "Evidence evaluations for Australian Drinking Water Guidelines chemical fact sheet - PFOS, PFHxS, PFOA PFBS and GenX chemicals (amended 3 October 2024)
- NHMRC table of stakeholder comments and SLR responses

My overall impression is that the SLR responses and corresponding document edits are thorough and well supported by extensive detail.

I note that the more significant changes to the documents relate to discussion of the human relevance of thyroid changes and pancreatic neoplastic lesions seen in rat studies, and consequent changes to the options for guideline values for PFOS and PFOA.

While I agree in general terms with the conclusions drawn by SLR about PFOS-induced changes in thyroid hormone status in the rat (and I agree with the reasoning relating to potential secondary hypothyroidism, the absence of related histopathology and the lack of corroboration from other rat studies), discarding this endpoint for the PFOS POD introduces some doubt about the relevance of this endpoint as it was used for PFHxS and PFBS, an issue I commented on in my previous review. This point has been acknowledged in revised discussion in relevant parts of the documents and I agree that the use of this thyroid endpoint remains appropriate for PFHxS and PFBS, despite the uncertainty about human relevance. I note that adoption of the NOAEL for extramedullary haematopoiesis results in a PFOS water quality guideline value now more consistent with the current 70 ng/L value and the discussion around this point is appropriate.

The main unresolved issue is whether it is more appropriate to calculate the POD from measured, or modelled estimates of serum PFOS from the relevant NTP study. Like SLR, I am unable to determine why there is such a marked difference between the modelled and measured values, but I agree that higher confidence could be accorded to a guideline value based on the measured data. I also note that the revised guideline incorporates an 300x UF (additional 10x based on the use of a 28-day study, rather than a chronic study). Given my previous comments about the application of different UFs, if an UF less than the conservative 300x could be justified, it would result in an even higher PFOS guideline value and add further weight to the contention that the existing value of 70 ng/L is suitably health-protective. In general, I found the SLR discussion of UFs applied across the various studies is informative and well-founded.

With regard to the possible revised guideline value of 401 ng/L for PFOA, I note that SLR now proposes not to use the neoplastic endpoint (pancreatic acinar adenomas and adenocarcinomas) for PFOA. While this addresses some of the points I made in my original review about whether a neoplastic or non-neoplastic endpoint could be more suitable,

I am in general agreement that the PFOA POD for the critical non-neoplastic effect (liver necrosis) is the more appropriate endpoint for guideline derivation, notwithstanding the discussion that confidence in the human relevance of this liver endpoint may be only slightly greater than that for human relevance of the neoplastic pancreatic lesions. I note that this approach results in a new and lower value for the ADWG guideline value for PFOA, and I agree that this is appropriate.

Tables 5.1 and 5.2 in the original SLR report detail the health-based guidance values (HBGV) and drinking water guidance values derived across multiple jurisdictions. These tables are useful because they illustrate the variability in both the numbers derived and the methodologies used to derive them. There is some discussion of the reasons for this variability in the SLR report, but, given the inevitable public disquiet about the NHMRC possibly adopting values higher than some other jurisdictions, I wonder if it might be useful to include a more specific statement along the lines ….." *Despite the variability between jurisdictions in the numbers generated, they were all considered to be conservative and protective of human health at the time they were published. The differences are due mainly to the selection of the most appropriate study and health endpoint, especially if the human relevance is less certain, and the inherent conservatism based on the extent to which uncertainty has been factored into the calculations. Adoption of a lower value by any jurisdiction does not necessarily imply a greater degree of health protection, nor does a higher value imply that conservatism has been too far eroded.* "

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Appendix D - Declarations of interest

The declarations of interest of Committee and Chemical Subgroup members at the time of their involvement in the development of the guidance are listed in the table below.

Consideration of the declarations of interests of members of the Water Quality Advisory Committee during the period 2022-2025 were undertaken according to NHMRC committee policy at the time.

2022-2025 Water Quality Advisory Committee

Name/Position	Area of Expertise	Declaration of Interests
Professor Nicholas J. Ashbolt (Chair) Cooperative Research Centre for Solving Antimicrobial Resistance in Agribusiness, Food and Environments, University of South Australia	Extensive experience in health-related water microbiology as a researcher/ academic, mostly in the field of environmental pathogen detection, fate and transport interpretation (via Quantitative Microbial Risk Assessment)	• Executive Dean, Faculty of Science and Environment, Southern Cross University (2019-2023). • WHO Technical Advisory Group on Water Quality and Health (since 2015-current), for input into drinking, recreational and reuse guidance documents and microbial pathogen performance of on-site drinking water treatment devices. • Water Research Foundation (WRF) Academic Advisory Committee (2016-2019) and Project Advisor Committee (PAC, 2019-2022) for WRF 5040, Successful Implementation of Decentralized Reuse and Treatment Systems. • National Water Research Institute (NWRI) expert panel member (2015-2021) on various non-potable water risk management and regulation projects. • Editor in Chief voluntary role as part of his professional contributions as a Fellow of the International Water Association. • Led water microbiology research into premise plumbing pathogens (e.g. Legionella pneumophila, Pseudomonas aeruginosa, non-tuberculous mycobacteria) and the role of free-living amoeba hosts that also supported viable human enteric viruses through treatment processes and environmental dissemination. • Numerous national and international research grants and collaborations • Has consulted on wastewater reuse • Royalties from patents managed by Macquarie University, Australia • Partner works for company Water^3 • Senior editor for HealthStream, a quarterly newsletter from Water Research Australia (WaterRA) that summarizes international literature relevant to the drinking water industry and notes recent outbreaks or investigations • Travel, accommodation and workshop paid by SUEZ CIRSEE (Paris) for role as a mentor for their Health and Environment postgraduate conference, Cannes, France June 26-28, 2023 and technical advisory team with four other invited senior academics across England, France and Australia.

Name/Position	Area of Expertise	Declaration of Interests
		• Involvement in risk assessment projects with the Cooperative Research Centre for Solving Antimicrobial Resistance in Agribusiness, Food and Environments (CRC SAAFE) with Water RA and the South Australia Environment Protection Authority.
Professor Cynthia Joll Deputy Director, Curtin Water Quality Research Centre, Curtin University	Expertise in analytical chemistry with a focus on disinfection by-products, both in terms of formation, detection and analysis of the chemicals.	• Previously Deputy Director, Curtin Water Quality Research Centre, Curtin University. The Curtin Water Quality Research Centre was a Strategic Research Alliance with the Water Corporation of WA. Member representative for Curtin University to Water Research Australia. Currently, Professor and Leader of the Curtin Water Quality Research Group. • Chief Investigator on past ARC Linkage projects on disinfection by-products in drinking water systems, and other drinking water and wastewater projects, with partner organisations Water Corporation of WA and Water Research Australia. • Current, past and future projects funded by water utilities on wastewater treatment, water recycling, and drinking water treatment and distribution, including formation of disinfection by-products and analysis of their concentrations in drinking water distribution systems. • Published numerous research papers, conference publications, reports, books and book chapters on wastewater treatment, water recycling, source water quality and drinking water treatment and distribution, including disinfection by-products. • Participation in national and international academic and industry conferences • Current, past and future projects funded by industry partners, government (e.g. NESP) and CSIRO on PFAS in drinking waters, wastewaters, water recycling and manufactured and waste products (e.g. for recycling purposes). • Lectures at Curtin University on environmental chemistry, water chemistry and analytical chemistry. • Travel support to attend research meetings of Water Research Australia where topics such as drinking water treatment and disinfection by-products have been discussed. • Current, past and future projects funded by the water industry relating to corrosion and metal concentrations in drinking water distribution systems
Dr David Cunliffe Principal Water Quality Adviser Health Regulation and Protection SA Health	Expertise in water regulation, microbiology and risk assessment.	• Provide specialist advice and policy on public health aspects of water quality including management and provision of drinking water, management and use of recycled water and use of recreational waters. • Contribution to WHO Drinking Water Guidelines leading to publication of background documents (e.g. on toxic cyanobacteria in 2021), specialist texts and two addenda to the 4th edition of the guidelines. • Occasional invitations to provide keynote presentations at international meetings.

Name/Position	Area of Expertise	Declaration of Interests
		• Published a number of scientific research journal articles • Contributed to: WHO (2021) Water, sanitation, hygiene, and waste management for SARS-CoV-2, the virus that causes COVID-19, NRMMC/EPHC/NHMRC (2008) Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2). Augmentation of Drinking Water Supplies, enHealth Guidance on the Use of Rainwater Tanks and Numerous fact sheets and guidance documents for the SA Department for Health and Wellbeing on drinking water and recreational waters • Membership of the program committees including for the Singapore International Water Week and Australian Water Association Annual Conference OzWater. • Membership of the International Water Association and Australian Water Association. • Membership of the Hong Kong Drinking Water Safety Advisory Committee from 2018. • Chair of the enHealth Water Quality Expert Reference Panel since 2017. • Chair of the External Audit Panel Singapore Public Utilities Board since 2020. • Chair of the WHO Drinking Water Guideline Coordinating Committee. • Has published papers on water quality related issues. • Involvement in risk assessment projects with the Cooperative Research Centre for Solving Antimicrobial Resistance in Agribusiness, Food and Environments (CRC SAAFE) with Water RA and the South Australia Environment Protection Authority.
Mr Cameron Dalgleish State Water Officer Tasmanian Department of Health	Expertise in environmental science, water quality and risk management, auditing, public health.	• Health regulator for drinking water safety in Tasmania; administering legislation, policy and guidelines for both drinking water quality and fluoridation. A working understanding of the implementation of the ADWG framework • An environmental scientist specialising in water chemistry with over 20 years' experience in the water industry. Previously worked across construction, natural resource conservation, environmental management and as a health regulator. • Appointments: Member of the enHealth Water Quality Expert Reference Panel, the National Recycled Water Regulators Forum and the Australian Water Association. Secretariat of the Tasmanian Fluoridation Committee. • Department of Health Tasmania Member Representative to Water Research Australia. • Has published journal articles, reports, fact sheets, guidelines and presentations at national conferences, seminars and workshops. • Public Servant: State Water Officer, Department of Health Tasmania. • Project contributor for the development of Operator Competencies in the water industry and development of a

Name/Position	Area of Expertise	Declaration of Interests
		WaterVal granular media filter validation protocol, both coordinated by Water Research Australia. • Areas of expertise: Environmental science, water quality and chemistry, risk management, auditing, public health. • Holds stock market investments, and partner is a joint investor in managed fund investments. Neither have influence in the selection of shares purchased on their behalf.
Professor Frederic Leusch School of Environment and Science, Griffith University	Expertise in environmental toxicology, chemical pollutants in the environment, endocrine disruption, bioanalytical tools in water quality assessment, chemical risk assessment and guideline development.	• Several consultancies funded by water industry, specifically on contaminants of emerging concern. • ARC Linkage grants include many water utilities in Australia (including Water Research Australia). • Previous member of the Project Review Team for Water Research Australia, which reviews research projects submitted for Water RA funding and provide advice on suitability to Water RA's research agenda. • Received travel support from Water Research Australia to present on research supported by Water RA at their annual research conference. • Teaches on water quality issues at Griffith University and has given lectures at various institutions on water quality issues and various drinking water guidelines. • Previously involved on the Commonwealth Games Independent Expert Panel on water quality, providing advice on water quality and monitoring programme for the 2018 Commonwealth Games. • Many publications on water quality, all published in peer-reviewed journals. • Independent Advisory Panel Member in the Faure New Water Scheme, Cape Town, South Africa. • Member of the Advisory Committee on the Environmental Management of Industrial Chemicals (IChEMS Advisory Committee).
Dr Harriet Whiley Associate Professor in Environmental Health, Flinders University	Leads the Flinders Water Quality and Health Research Consortium and is the Water and Health theme leaders for the Biofilm Research and Innovation Consortium	• Holds an indirect, non-pecuniary interest through my role as SA Branch Committee Member for the Australian Water Association (2021-2022). • Holds an indirect financial interest through my ongoing research collaborations with Enware, a manufacturer and distributer of commercial and industrial plumbing products. • Flinders University representative for Water Research Australia. • Numerous past, present and current research projects on water quality which have received both grant and industry funding. This includes research on biofilms, opportunistic pathogens, rainwater, plumbing materials and risk management approaches. • Has published in academic journals and industry magazines on topics such as lead and water quality risks. • Has presented at academic and industry conferences and workshops. • Holds an indirect, non-pecuniary interest through her role on the Legionella Management Advisory Group.

Name/Position	Area of Expertise	Declaration of Interests
		• Deputy Director of the ARC ITTC for Biofilm Research & Innovation • Holds an indirect, non-pecuniary interest through her role on the Legionella Management Advisory Group.
Dr Bala Vigneswaran NSW Department of Climate Change, Energy, the Environment and Water	Experience in water-related public health, water microbiology, water chemistry, water recycling, hydrology, water quality risk assessment and risk management	• Previously served in New South Wales regional councils for over five years in positions concerning water resources, water treatment processes and system compliance.
Mr Peter Rogers Water and public health expert	Expertise in critically analysing scientific evidence in public health including the areas of drinking water quality, wastewater management, beach water quality, asbestos management and disaster management.	• Former Principal Policy Development Officer – Water and Wastewater portfolio, Northern Territory Department of Health
Ms Nicola Slavin Principal Policy Officer, Northern Territory Department of Health	Expertise in Indigenous Environmental Health and Public Health policies, strategies and legislation.	• Northern Territory representative on enHealth Water Quality Expert Reference Panel and the National Recycled Water Regulators Subgroup • Northern Territory representative on enHealth Expert Reference Panel on Aboriginal and Torres Strait Islander Environmental Health
Mr Laurence Wilson (Observer) National Indigenous Australians Agency		• No interests declared
Mr Adam Lovell (Observer 2022-2023) Water Services Association of Australia (WSAA)	Peak industry body representing the urban water industry.	• Water Services Association of Australia (WSAA) - Executive Director • Global Water Research Coalition (GWRC) – Board Chair • The GWRC is a non-profit organisation that serves as a focal point for the global collaboration for research planning and execution on water and wastewater related issues.
Ms Yulia Cuthbertson (Observer, since 2024)	Represents interests of the Department of Climate Change, Energy, the Environment and Water and the Water Quality team from the	• No interests declared

Name/Position	Area of Expertise	Declaration of Interests
Department of Climate Change, Energy, the Environment and Water	National Strategies and Assessments section of the Water Policy Division in particular	