Independent Review of land uses around key Defence bases impacted by PFAS contamination

MARCH 2024

Jim Varghese AM, Chair, The Leadership Company Qld Pty Ltd

In the spirit of reconciliation the Independent Reviewer and the Secretariat acknowledge the Traditional Custodians of Country throughout Australia and their connections to land, sea and community. We pay our respects to their Elders past and present, and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

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Jim Varghese AM
Chair, The Leadership Company Qld Pty Ltd

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About the Independent Reviewer

Jim Varghese AM is the Chair and owner of The Leadership Company Qld Pty Ltd, Chancellor of Torrens University, Independent Chair of the City of Springfield Board of Directors, and a director of several private and not-for-profit companies.

Jim has unrivalled experience in both the public and the private sectors. He spent 30 years of his career in the Victorian and Queensland public sectors, holding roles including Directors-General of Transport, Main Roads, Education, Training, Employment and Primary Industries.

He has spent time in the private sector, including more than 15 years at the Springfield City Group, which established Australia's only master planned city built by the private sector to create public and private value.

Jim's credentials in good governance include being a fellow Certified Practising Accountant, fellow of the Australian Institute of Management, fellow of the Royal Institute of Public Administration, fellow of the Australian Marketing Institute, and a member of the Australian Institute of Company Directors.

Jim created the 'Three Frames' management approach, which aligns outcomes with congruent relationships, structures, systems and capabilities.

He was awarded the Centenary Medal for services to the Public Sector and later received an Order of Australia for Services to Public Sector Reform and Services to the Community.

In 2015, Jim was appointed Chair of the Queensland Government's Opportunities for Personalised Transport Review into ride-sharing arrangements. In 2018, the Red Meat Advisory Council, in collaboration with the then Federal Minister for Agriculture under the coalition government, appointed him to recommend changes to its industry to meet the challenges of the twenty-first century. In 2021, the Queensland Government appointed Jim to review the structure of the Queensland Building and Construction Commission.

Jim's recent accomplishments include appointments as a member of the Queensland Independent Remuneration Tribunal and Chair of Jobs Queensland.

Independent Reviewer's foreword

I am confident that recommendations from this Review will assist in realising the best use of PFAS-impacted land around RAAF Base Williamtown in New South Wales, Swartz Barracks (formerly known as the Army Aviation Centre Oakey) in Queensland and RAAF Base Tindal in the Northern Territory.

While I consider that most land uses can continue, I have recommended that independent assessors be appointed to assess risk in the context of land use at a property level.

I have consulted widely in conducting this Independent Review for the Australian Government, including with community members, Indigenous communities, representatives of academia, industry, senior officials and elected representatives from all levels of government. I have considered input received through submissions, public hearings and forums. There has been a thorough examination of the previous inquiries conducted through the Australian Parliament to avoid unnecessary duplication of work.

As I have conducted this Review, many community members expressed to me their frustration, anger, disillusionment, hopelessness and cynicism. Others have expressed optimism, opportunity and hope that the Review will offer a way ahead.

All stakeholders want this Review to provide a way forward, even though this tends to mean something different to each person and organisation.

I sincerely appreciate the willingness of community members to engage with the Independent Review and to take the time to clearly express how PFAS contamination has affected them.

While acknowledging the concerns that have been expressed to me, I have endeavoured to focus on positives and to transform negatives, wherever practicable.

I congratulate the Government in acknowledging community concerns about the broader impacts including on health, the environment, and food sources.

The Review recommends that far greater information be placed in the hands of community stakeholders than they have had before.

In this context, a positive initiative would be to publish an annual update of the status of technologies or 'antidotes' for the remediation of soil, surface water and groundwater surrounding PFAS-impacted sites, and remediation of broad-scale, low-level PFAS contamination.

The Review provides a blueprint for Government to resolve the most pressing issues resulting from PFAS contamination.

I hope this report will prompt simultaneous action for immediate steps to address the most pressing needs of the community and provide a strategic policy framework to ensure short, medium and long term outcomes.

I believe there is an unrivalled opportunity for federal, state/ territory and local governments to collaborate effectively to address the serious needs of the community.

It would be disappointing for this Independent Review to be regarded as "just another review" and such treatment could upset and anger affected communities and industry. This may increase scepticism and lower confidence towards the governments of Australia to genuinely address concerns and expectations around PFAS contamination issues.

I have used my Three Frames methodology to conduct the Review:

- Performance frame - specifying outcomes to ensure clarity around the Terms of Reference of the Review
- Relationship frame - identifying and understanding all key stakeholders
- Alignment frame
  - achieving congruence between the Independent Reviewer, the Review Secretariat and the associated capability to meet all the requirements of the performance frame
  - listening to and evaluating both negative and positive feedback
  - sustaining and nourishing the capability of the team and associated leadership.

Each recommendation and action integrates outcomes with key relationships and alignment, and addresses the gap from 'where we are now' to 'where we want to be'.

Effective implementation will support the future use of land in areas surrounding RAAF Base Williamtown, Swartz Barracks and RAAF Base Tindal.

I would like to acknowledge the work of the members of the Independent Review Secretariat, who have been tireless in their effort, professional in their approach, and undaunted by workloads and timeframes.

I also acknowledge the Australian National University for its scholarly review and advice on human health impacts of exposure to PFAS, Aurecon Australasia Pty Ltd for its assistance in helping to illustrate the potential for social, economic and natural capital precincts, and the University of Newcastle and the University of Queensland for their advice on PFAS issues more broadly.

Jim Varghese AM

Introduction

The use of PFAS in consumer products and industrial applications has been extensive in Australia for many years.

It was present in certain firefighting foams that were widely used, including at Defence bases, due to its effectiveness in fighting liquid fuel fires.

Over time, PFAS chemicals moved through the soil to contaminate surface and ground water, and migrated into adjoining land areas.

This Review sets out recommendations to help Government make decisions regarding land use and zoning around the three Defence sites impacted by PFAS as specified in the Terms of Reference.

The recommendations are designed to facilitate a holistic and effective government response to PFAS contamination in a local context. Implementing the recommendations will ensure that key information is regularly updated, and is made available to property owners and other stakeholders to inform decisions on land use and development. They will help to clarify the outlook for local PFAS contamination and local planning, and enable private sector investment in master planned precincts.

These recommendations provide a platform for integrated Commonwealth, state/ territory and local government responses that embrace continuous improvement, promote better understanding of PFAS, and closely monitor remediation technologies to PFAS contamination.

The recommendations of this Review build on the recommendations from previous Parliamentary inquiries into PFAS contamination — in part this reflects that many issues of most concern to impacted communities and stakeholders have not yet been fully addressed.

Outcomes from the Defence Estate Audit and this Review are likely to align well, particularly as they relate to longer-term Defence priorities and planning for development on and around the Defence estate.

While the Review has focussed on RAAF Base Williamtown in New South Wales, Swartz Barracks in Queensland and RAAF Base Tindal in the Northern Territory, there is scope for elements of the recommendations to have broader applicability to other Defence and Commonwealth sites including leased federal airports, and other sites impacted by PFAS contamination across Australia.

The recommendations and actions outlined in this report respond to the Terms of Reference in Attachment A, which are summarised below:

- Consider land use options with a view to assisting people and businesses impacted by PFAS contamination
- Explore use and voluntary repurposing of impacted land, including for industrial use and particularly for defence industry
- Focus on land and communities around RAAF Base Williamtown, Swartz Barracks, and RAAF Base Tindal
- Seek submissions from the public and key stakeholders, and conduct public hearings
- Work in consultation with federal, state/ territory and local governments and agencies, landowners, industry, and Traditional Owners and Indigenous communities
- Seek information from state/ territory and local governments to understand how information about PFAS contamination informs planning and development
- Make recommendations regarding decision-making for land use and zoning around the three Defence bases.
- Inform the Government's policy options for managing impacts of PFAS contamination
- Consider (a) existing mechanisms for determining land uses (b) jurisdictional considerations (c) varying PFAS contaminations frameworks across jurisdictions and (d) the profile of potentially impacted properties, and thresholds or criteria that would trigger an assessment of land use
- Note that the Review is expected to have implications for other Commonwealth sites, including leased federal airports
- Consider and complement the Defence PFAS Investigation and Management Program
- Note that the Government acknowledges community concerns about broader impacts of PFAS contamination, including on health, environment and food sources
- Take into account the findings of, and avoid unnecessary duplication with, previous reviews and inquiries into PFAS contamination.

Executive summary

This Independent Review was commissioned to consider decision-making for land use and zoning of land impacted by PFAS around RAAF Base Williamtown (in Williamtown, New South Wales), Swartz Barracks (near Oakey, Queensland) and RAAF Base Tindal (near Katherine, Northern Territory). This Review has identified a range of issues that are of greatest concern to property owners across the three communities, and has proposed recommendations and actions to address them.

The Australian Government has indicated that this Review will inform policy options for managing the impacts of PFAS contamination. However, each community is different and there is no one-size-fits-all solution to address impacts of PFAS contamination at each site.

Responsibility for planning, development and environmental management around Defence bases resides with relevant state/ territory and local governments. The Review has considered jurisdictional responsibilities for properties impacted by PFAS contamination and has made recommendations in the context of a nationally coordinated response.

The Independent Reviewer recommends that the Australian Government work closely with all jurisdictions to maximise the benefits for communities from this Review.

Since 2016, the Australian Government has undertaken a range of activities to respond to PFAS contamination. These actions have focussed on minimising individual and community exposure to PFAS, addressing risks to human health and the environment, reducing the continued movement of PFAS, research and development, and providing information to impacted communities. The PFAS National Environmental Management Plan specifically recognises the importance of managing PFAS contamination in a way that maintains environmental values, including future land use options.[1]

The Australian Parliament has previously conducted a number of inquiries into PFAS contamination. During this Review, many community members expressed frustration that they had already told previous inquiries of their concerns and issues, and some recommendations from those inquiries remain unresolved.

The Review has noted the large number of legal claims made against the Commonwealth as a result of PFAS contamination arising from Defence's use of legacy firefighting foams. These comprise non-litigated and litigated claims (including class actions). The vast majority of claims have been made for alleged diminution in property value, and for alleged inconvenience, distress and vexation. The Independent Reviewer understands that some property owners who have settled a legal claim with the Commonwealth (including through class actions) are likely to have received some compensation for impacts on land use resulting from PFAS contamination. The Independent Reviewer cannot comment on the quantum of compensation paid, but acknowledges the continuing frustration and concerns of some community members, including those who have received compensation.

1 Department of Climate Change, Energy, the Environment and Water, Heads of EPAs Australia and New Zealand, *PFAS National Environmental Management Plan Version 2.0*, Commonwealth of Australia, 2020.

Key themes identified during the Review

The Review has identified common themes relating to how stakeholders make decisions about land uses in the context of PFAS contamination in the three communities.

The themes were identified during extensive stakeholder consultation, engagement and analysis of information received.

The report is structured in line with the key themes:

National coordination
The impacts of PFAS contamination (including on the environment, human health, food production, and planning and development) are beyond the remit of any single entity. Agencies across all levels of government do not appear to work well together to deliver an effective response to impacted communities. It is often up to communities to identify problems and suggest solutions.

Access to information
Communities are concerned about the currency and accuracy of advice from Australian governments about PFAS contamination. They want credible, relevant, and up-to-date information that they can trust. They want information to be in plain English so they can understand what contamination means for them and for their individual circumstances and land uses. They want to know what they can do with their land, not just what they cannot do with their land.

Transparency about PFAS management and remediation
Impacted communities want to understand whether remediation will be effective, and how long it will take. There are unintended consequences from establishing PFAS management areas, including relating to property valuations and financial lending practices. These remain a source of great concern for impacted communities.

Principles to support improved decision-making for land use and planning
Some property owners continue to live on land that is contaminated and are concerned that this limits how they can use their land. They are concerned that they cannot sell their land at a fair market price. The Independent Reviewer noted differences in land use planning and zoning across jurisdictions, and that planning frameworks typically do not apply retrospectively (including to account for historical PFAS contamination). Some local governments would support more guidance and specific planning controls to help them plan for, and manage, contaminated land.

Managing risk associated with land uses in PFAS management areas
Some property owners are concerned that precautionary advice does not protect them from contamination. Others indicated that the precautionary advice is not feasible to implement. People growing food are concerned about advice that they should not eat their own produce, but can sell it into the market. Other food producers are concerned about evolving international approaches to management of PFAS in foods. They want advice and support from governments to address these issues.

Social, economic and natural capital precincts
Some property owners want choices and options for what they can do with their land where precautionary advice imposes limits. Voluntary rezoning and repurposing of land would provide such choices and options. Stakeholders support a range of suitable options for voluntary repurposing. These include use of land by industry, or for broader environmental outcomes such as biodiversity and nature repair.

This Review provides recommendations under each of the themes that deliver a combination of short, medium and long-term benefits, with a number of recommendations to be implemented immediately. The recommendations were also informed by targeted research and advice from industry and academia.

The Review acknowledges that there is no single recommendation that will provide a perfect solution for all community members and stakeholders. Some recommendations build on the work already being undertaken by governments and will promote improvements. When taken together, these recommendations provide a framework through which impacts of PFAS contamination can be managed effectively and holistically. They also map a path to unprecedented cooperation between all levels of government to empower property owners and help restore choices about how they use their land.

Implementation of recommendations should be aligned to the development of new national environmental laws being introduced by the Australian Government, including establishing Environment Protection Australia – the national environment protection agency function.[2] Implementation should also be aligned with the establishment of the new Australian Centre for Disease Control, with its remit to strengthen partnerships with stakeholders and to provide transparent and consistent public health advice.[3] These developments offer a significant opportunity to better coordinate the national response to PFAS contamination, and to ensure the response prioritises both the environmental and health impacts of PFAS contamination, including mental health.

2 Department of Climate Change, Energy, the Environment and Water (DCCEEW), *EPBC Act reform*, DCCEEW website, 2024. https://www.dcceew.gov.au/environment/epbc/epbc-act-reform#toc_2>.

3 Department of Health and Aged Care, *Australian Centre for Disease Control*, Department of Health and Aged Care website, 2024. https://www.health.gov.au/our-work/Australian-CDC

Summary of Recommendations and Actions

National coordination: Recommendation 1

Recommendation 1: That the Australian Government take immediate action to strengthen coordination and integration of the response to PFAS contamination across and between the Commonwealth, state/ territory and local governments.

Actions to implement

- As a priority, the Australian Government should establish a national coordinating body with representation from Commonwealth agencies with key policy responsibilities informing the response to PFAS contamination, and from state/ territory and local governments.
- The national coordinating body and working groups should develop Terms of Reference and objectives to guide their work. These should be developed through co-design with community, Indigenous communities and industry representatives.
- The national coordinating body should establish location-based and thematic working groups to drive progress on priority issues. Such working groups should include representation from relevant Commonwealth, state/ territory and local governments, and should engage with local communities, Indigenous communities and industry representatives.
- The Australian Government should ensure the national coordinating body is appropriately resourced. The national coordinating body should explore opportunities to more effectively and efficiently achieve whole-of-government outcomes, noting that there is already significant expenditure in responding to PFAS contamination across Commonwealth agencies and state/ territory governments. Potential legal actions by the Commonwealth against manufacturers of PFAS might provide an opportunity to recover some of the costs of contamination responses into the future.
- The national coordinating body should ensure transparency and accountability of outcomes for impacted communities, and for delivery of relevant recommendations in this Review, through annual public reporting to the Australian Government.

Access to information: Recommendations 2-4

Recommendation 2: That the national coordinating body enhance the availability of credible, relevant and up-to-date information on impacts of PFAS contamination to assist in addressing community concerns and to enable existing land uses. This includes taking immediate action to update the work undertaken by the PFAS Expert Health Panel which reported in May 2018.

Recommendation 3: That Defence and state/ territory authorities provide information to property owners on impacts of PFAS contamination that considers their individual circumstances.

Recommendation 4: That Defence and state/ territory authorities take early action to improve the availability of culturally-appropriate and tailored advice on impacts of PFAS contamination for Indigenous communities who access and use land surrounding RAAF Base Williamtown, Swartz Barracks and RAAF Base Tindal.

Actions to implement:

- The national coordinating body should review and maintain the content available on **www.** pfas.gov.au.

- The national coordinating body should ensure key public guidance is updated and maintained, including:
  - the work published by the PFAS Expert Health Panel in May 2018
  - the Australian Drinking Water Guidelines (the Independent Reviewer understands this work is underway)
  - the PFAS Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination
  - additional guidance for primary producers to meet national and international standards for PFAS in food (the Independent Reviewer understands this work is underway)
  - an annual status report of technologies for the remediation of PFAS in soil, surface water and groundwater.
- The national coordinating body should ensure advice is provided on:
  - implications for Australia of key developments in international approaches to responding to PFAS, including work underway through the World Health Organization
  - progress in implementing the Industrial Chemicals Environmental Management Standard to meet internationally accepted standards under the Stockholm Convention
  - the status of research previously commissioned by the Australian Government, including grants managed through the Australian Research Council and the National Health and Medical Research Council; and the need for additional research
  - information general practitioners can provide to their patients about human health impacts of exposure to PFAS contamination
  - the need for human health and ecological guidance for PFAS compounds other than perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS).
- Defence should work with the national coordinating body to appoint local Community Liaison Officers for the three sites, to provide advice to property owners that is informed by local circumstances, link community members to available services, and work across all levels of government.
- Defence should continue to work with state/territory authorities to provide PFAS sampling to property owners on request, with plain English advice on what results mean in the context of applicable land uses.
- Defence should conduct environmental PFAS sampling to provide Indigenous communities with an increased understanding of contamination in local soil, surface water, groundwater and biota; and work with state/territory authorities to provide culturally-appropriate information (for example in relevant language) on how the results relate to cultural needs.

Transparency about PFAS management and remediation: Recommendations 5-8

Recommendation 5: That the national coordinating body consider options to mitigate unintended consequences of establishing PFAS management areas and zones, including property valuations and financial lending practices, stigma, and the inclusion of properties that have no or very minimal contamination or risks of exposure to contamination.

Recommendation 6: That Defence and state/territory authorities take immediate action to confirm that site-specific human health risk assessments, PFAS management areas and zones, and precautionary advice around the three sites remain current. This should occur in consultation with the national coordinating body to promote consistency.

Recommendation 7: That Defence and state/territory authorities take early action to publish plain English advice on the prospects for remediation of land and water within the three PFAS management areas. This should address the feasibility of relevant remediation technologies, timeframes, sustainability, cost and options for management of residual risks. This should occur in consultation with the national coordinating body to promote consistency.

Recommendation 8: That the national coordinating body review the objectives of national policy for remediation of PFAS contamination to ensure they remain current. This should consider the limitations and practical application of commercially available technologies, and inform long-term management of residual risks.

Actions to implement:

- As a priority, Defence should work with state/ territory authorities to identify the data needed to support a review of human health risk assessments and precautionary advice for the three sites. This should occur in consultation with the national coordinating body to promote consistency.
- Defence and state/ territory authorities should work together to ensure a common understanding of remediation challenges and opportunities around the three sites. This should occur in consultation with the national coordinating body to promote consistency.

Principles to support improved decision-making for land use and planning: Recommendations 9-10

Recommendation 9: That the national coordinating body consider the need for further national guidance regarding planning and development in the context of historical contamination that may impact existing land uses. Any new guidance could be implemented through state/ territory and local government frameworks.

Recommendation 10: That the national coordinating body consider the merits of providing further national guidance regarding recording contamination on property titles, including to improve consistency across jurisdictions. Any new guidance could be implemented through state/ territory and local government frameworks.

Actions to implement:

- The national coordinating body should establish a working group to review relevant planning processes and guidance, including progress under the National Cabinet's priority of developing a 'National standard for considering disaster and climate risk in land use planning'.

Managing risk associated with land uses in PFAS management areas: Recommendations 11-15

Recommendation 11: That the national coordinating body ensure additional policy guidance is developed to address risks associated with food production in the context of PFAS contamination, including developing new Health Investigation Levels that will inform risk assessments for the suitability of relevant land uses.

Recommendation 12: That the national coordinating body ensure early action is taken to develop additional guidance for primary producers to meet national and international standards for PFAS in food.

Recommendation 13: In the context of Recommendations 7 and 12, that the national coordinating body take immediate action to appoint an independent assessor to work with Commonwealth and state/ territory authorities to identify primary producers in management areas around the three sites. If measures to meet European Union and other potential international standards for PFAS in foods are assessed as not being feasible to implement and residual risk exists, the Commonwealth should consider working collaboratively with state/ territory and local governments to provide additional support to producers.

Recommendation 14: In the context of Recommendations 2, 6 and 7, that Defence work with the national coordinating body and the New South Wales Government to take immediate action to appoint an independent assessor to assess PFAS exposure risks for properties in the RAAF Base Williamtown Primary Management Zone. If human health exposure risks for residents of a property cannot reasonably be mitigated, for example through implementing precautionary advice or remediation activities, the Australian Government should consider working collaboratively with state/ territory and local governments to provide additional support to the property owner. This could include rezoning or the voluntary acquisition of properties, including by state/ territory or local governments. Outcomes of these assessments would inform options for the Australian Government to manage risks in other zones in the Williamtown Management Area, and in the PFAS management areas around Swartz Barracks and RAAF Base Tindal.

Recommendation 15: That Defence work with the national coordinating body to take immediate action to establish an effective and impartial mediator/ mediation panel, empowered to hear from property owners in the PFAS management areas around the three sites and address residual concerns or claims as a result of PFAS contamination. This mediation process would complement the existing legal claims process. Mediation would occur within an established framework to guide the nature of issues to be considered by the independent mediator/ mediation panel, and how resolution may be achieved. Some property owners have settled legal claims relating to PFAS contamination with the Commonwealth, including through class action processes. The terms of those settlements may be relevant to whether individual property owners have further recourse to a mediation process.

Actions to implement

- Defence and the national coordinating body should commence development of a framework which identifies issues to be considered by the independent mediator or mediation panel and clarifies options for resolution of those issues.

Social, economic and natural capital precincts: Recommendations 16-19

Recommendation 16: That the national coordinating body develop national guidance and principles that strategically consider land uses in areas of higher PFAS contamination. These principles should be made suitable for implementation through state/ territory and local government frameworks.

Recommendation 17: That the national coordinating body take immediate action to establish a Williamtown Working Group to commence implementation of the strategic business case for a social, economic and natural capital precinct around RAAF Base Williamtown.

Recommendation 18: That the Williamtown Working Group identify and implement a structure to coordinate and manage performance and maintenance of the local drainage network.

Recommendation 19: That the national coordinating body take immediate action to establish Oakey and Tindal working groups to prepare a strategic business case for social, economic and natural capital precincts around Swartz Barracks and RAAF Base Tindal.

Actions to implement:

- The national coordinating body should ensure the Williamtown Working Group is appropriately resourced to commence development and fine tuning of the supporting business case.
- The Williamtown Working Group should progress some initial maintenance and infrastructure works on the local drainage network to alleviate immediate issues being experienced by property owners in the Primary Management Zone, including through assessing options for additional drainage outlets into Fullerton Cove.
- The national coordinating body should ensure the Oakey and Tindal working groups are appropriately resourced.

Background

During the 2022 federal election, the Australian Labor Party committed to an independent review exploring new opportunities for land and property impacted by PFAS contamination. The election commitment stated that PFAS contamination had resulted in diminished opportunities for land use by landowners, and that the review would support impacted landowners to explore future opportunities for use of affected land.[4]

The election commitment acknowledged that Defence was undertaking a national program to review, investigate and implement its approach to manage the impacts of PFAS on and around some of its bases. It also noted that this national program did not consider potential uses and repurposing of affected land as those were state/ territory and local government responsibilities.

On 20 September 2023, the Australian Government announced the commencement of the Review with Mr Jim Varghese AM as the Independent Reviewer.[5] In announcing the Review, the Australian Government noted that the Review was expected to be finalised by early 2024. The Hon Matt Thistlethwaite MP, Assistant Minister for Defence, said "The findings of this Review will be important in informing the Government about how to help communities affected by PFAS contamination around Defence bases."

Terms of Reference

The Australian Government provided the Independent Reviewer with Terms of Reference to govern the conduct of the Review (Attachment A).

The Review was required to explore other uses for land impacted by PFAS contamination, including through voluntary rezoning or repurposing. The Reviewer was asked to make recommendations about decision-making for land use and zoning in relevant areas.

The Review was to focus on land and communities around RAAF Base Williamtown (New South Wales), Swartz Barracks (formerly known as the Army Aviation Centre Oakey, Queensland) and RAAF Base Tindal (Northern Territory). In announcing the Review, the Australian Government noted that challenges faced by these communities were considered representative of those faced by other communities impacted by PFAS contamination from Defence bases.[6]

The Review was to consider, but not duplicate, the findings of previous reviews and inquiries into PFAS contamination.

The Review was required to deliver a report within six months of commencement.

4 Australian Labor Party, *Labor will review new uses for PFAS-affected properties* [media release], 6 May 2022.
5 Department of Defence, *Independent review of land uses around key Defence bases impacted by PFAS contamination* [media release], The Hon Matt Thistlethwaite MP, Assistant Minister for Defence, 20 September 2023.
6 Department of Defence, *Independent review of land uses around key Defence bases impacted by PFAS contamination* [media release], The Hon Matt Thistlethwaite MP, Assistant Minister for Defence, 20 September 2023.

Consultation

Authentic engagement and consultation has been critical to identify positive and negative aspects of the current response to PFAS contamination as it relates to land use, and to identify ideas and options to move forward.

The Review sought views from a wide range of stakeholders, including ministers and elected representatives from all levels of government, officials from relevant Commonwealth, state/ territory and local governments, industry, Traditional Owners and Indigenous communities, residents, and property and business owners.

The Review conducted engagement through multiple formats to maximise opportunities for participation and input:

- Submissions — 95 submissions were received, with the public call for submission being open from Monday 23 October 2023 until Sunday 3 December 2023.
- Public hearings — eight presentations were given by community representatives during public hearings in Williamtown, Oakey and Katherine, and an open virtual hearing.
- One-on-one meetings — over 30 one-on-one meetings were held across the three locations.
- Stakeholder meetings — over 100 meetings were held with key stakeholders.
- Requests for information — 15 responses to requests for information were received from various Commonwealth and state/ territory agencies, and local governments.
- Website — over 600 users visited the Review website (**www.pfasindependentreview.com.au**).
- Phone and email — over 90 enquiries were received via a dedicated phone and email service.

Attachment B provides further information around the consultation.

Context

There are many PFAS-contaminated sites around Australia resulting from chemicals being in firefighting foams and consumer products. PFAS are also present in waste streams, including at landfills and wastewater treatment facilities, and more broadly in the environment.[7]

Land use planning

State/ territory and local governments are responsible for making decisions about land use and zoning in those jurisdictions. The Commonwealth has jurisdiction for land use decisions on its land and waters, including Defence bases. Commonwealth and state/ territory responses to PFAS contamination are directly informed by the differing regulatory requirements in those jurisdictions.

In 2016, the former Council of Australian Governments committed to ongoing collaboration between all governments to support communities affected by PFAS, and implemented the Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination.[8] However, the lack of connectedness on issues of land use and planning remains a challenge to achieving satisfactory outcomes for impacted communities and property owners who are unable to fully use their land. The land planning principles and processes applied across local government areas are generally not retrospective in nature, and recognition of historical contamination is complex. Any changes to existing land uses typically require some form of compensation to be paid, where the change occurs outside of a new development scenario.

For instance, Queensland authorities advise that the planning framework allows for local planning schemes to include provisions that restrict or manage new land uses. Currently, this mechanism is limited to local planning schemes being changed to respond to natural hazards (e.g. flooding, bushfire or landslide) and impact upon new development. Where a change is made for any other matter, then landholders may be eligible for compensation where a change is made that affects their existing land use rights.

7 Department of Climate Change, Energy, the Environment and Water, Heads of EPAs Australia and New Zealand, *PFAS National Environmental Management Plan Version 2.0*, Commonwealth of Australia, 2020.

8 Council of Australian Governments (COAG), *Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination,* Federation website, 2020.

The Defence PFAS Investigation and Management Program

In 2015, Defence's national PFAS Investigation and Management Program was established to manage risks associated with PFAS contamination on and around Defence bases associated with the historic use of firefighting foams. The program commenced with reviews of where firefighting foams were used to identify the bases most likely to be impacted. This resulted in 28 Defence bases being prioritised for the Defence PFAS Investigation and Management Program.

Defence conducted PFAS environmental investigations into the nature and extent of PFAS contamination on and around each of these bases. The investigations consisted of environmental sampling to identify source areas (where foams were used and stored), pathways (how PFAS moves in the environment) and possible receptors (such as people and the environment). Human health and ecological risk assessments were conducted to assess possible risks. Defence's first priority was to address these risks by reducing exposure. This included providing alternate water supplies to communities drinking PFAS-impacted groundwater. In December 2023 the Australian Government extended the provision of water assistance for eligible communities (i.e. paying water access and usage charges, refilling of water tanks) to a total period of eight years, dating from when water assistance first commenced for each property.

On completion of the investigations, 'PFAS management areas' were defined (refer Figures 1-3). These represented geographical areas subject to PFAS risk management activities such as remediation, management and/ or monitoring. PFAS management areas, or smaller zones within an area, have also been defined in some cases to assist in managing potential risks. The Williamtown PFAS Management Area is the only PFAS management area not defined by Defence, and the area continues to be managed by the New South Wales Government.

Defence used the findings of each investigation to develop a PFAS Management Area Plan to address elevated risks at each site. The plans are site-specific and recommend actions, including remediation, to manage and reduce the risks of PFAS exposure, and reduce the continued movement of PFAS from sites. Defence is now implementing these plans.

Defence conducts ongoing monitoring, including of groundwater and surface water, to track changes in risk profiles and to inform management requirements. The monitoring also checks for improvements that may occur over time as a result of remedial works. Defence's goal for PFAS management is to minimise exposure risks so far as reasonably practicable. In the first instance, this means breaking exposure pathways to people by providing an alternate potable water supply (as required) and supporting precautionary advice issued by state/ territory governments. It also means minimising the movement of PFAS from Defence sites by remediating PFAS source areas. Defence advises that this is critical to achieving longer-term reductions to the levels of PFAS around Defence sites.

Remediation activities have included treatment of soil, groundwater, surface water and building materials. The characteristics of each site (e.g. soil, hydrogeology, hydraulic gradient) are unique and can influence how and where PFAS moves in the environment. These characteristics also influence how effective a remediation option may be at a particular site.

The PFAS National Environmental Management Plan advises that the following issues should be considered before choosing a remediation or treatment option:

- proportionality to risks
- sustainability of option
- views of affected communities and jurisdictional regulators
- availability of the best treatment or remediation technologies
- site-specific issues
- effectiveness of technology as demonstrated by destruction efficiency or the reduction in PFAS concentration
- treatment strategy
- validation
- understanding PFAS precursors.[9]

9 Department of Climate Change, Energy, the Environment and Water, Heads of EPAs Australia and New Zealand, *PFAS National Environmental Management Plan Version 2.0*, Commonwealth of Australia, 2020.

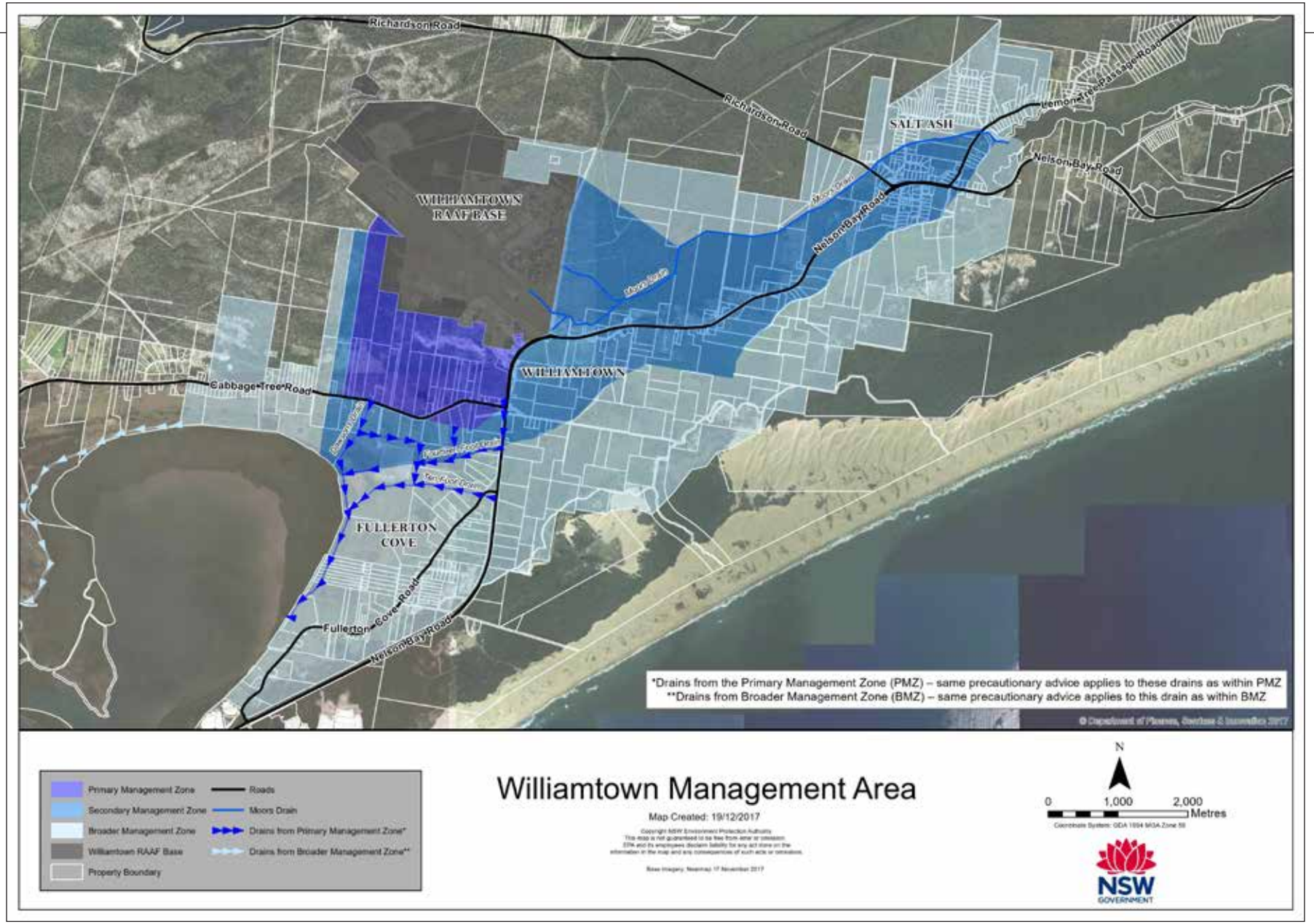


Figure 1: Williamtown Management Area

Figure 2: Swartz Barracks PFAS Management and Monitoring Areas (formerly known as Army Aviation Centre Oakey)

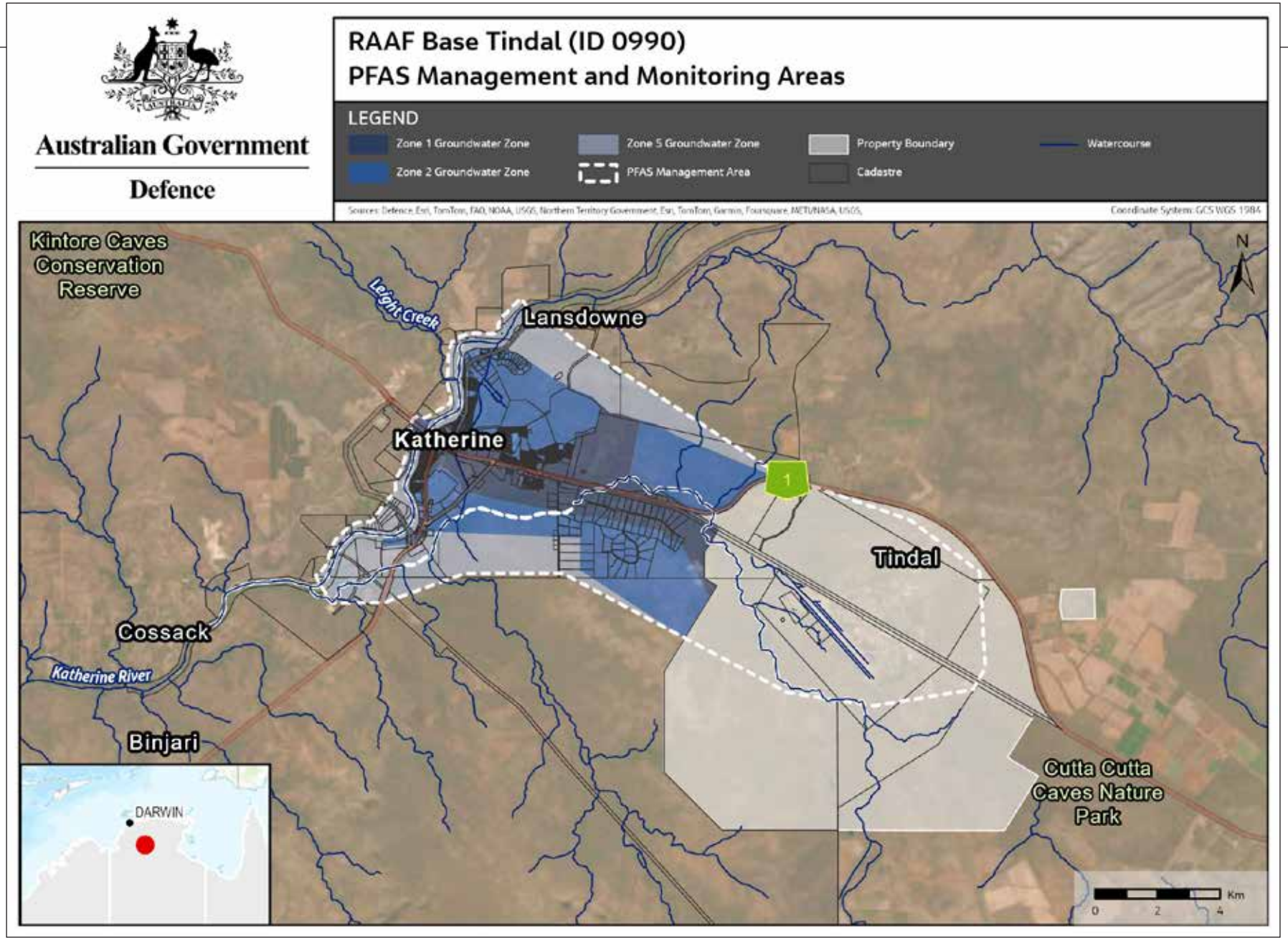


Figure 3: RAAF Base Tindal PFAS Management and Monitoring Areas

Defence provides PFAS-affected communities with information about investigation outcomes, and remediation and management activities. As of February 2024, Defence has conducted 178 community engagement events. Defence publishes reports, factsheets and other updates on the PFAS Investigation and Management Program website.[10]

On completion of environmental investigations and risk assessments, precautionary advice was issued for communities surrounding RAAF Base Williamtown and RAAF Base Tindal, to assist in reducing potential exposure. The Queensland Government did not issue site-specific precautionary advice for Swartz Barracks, but provided general advice to assist in reducing PFAS exposure risks.

Precautionary advice may apply to an entire PFAS management area, or to select properties or locations, and is typically provided by the relevant state/ territory government. It can also apply to waterways or bodies of water beyond PFAS management area boundaries. Depending on individual circumstances, precautionary advice may impact how property owners and businesses use their land. For example, precautionary advice issued by the New South Wales (NSW) Government for the Williamtown Primary Management Zone states:[11]

"The NSW Government is recommending that residents within the Primary Management Zone follow this precautionary advice to minimise their exposure to PFAS chemicals originating from the RAAF Base Williamtown:

1. **Groundwater, bore water and surface water should not be used for any purpose**
2. **Additionally, do not do anything with groundwater, bore water or surface water (including in creeks and drains) that might lead to incidental ingestion (swallowing)**
3. **Home grown foods produced in your area should not be consumed. This includes home-slaughtered meat, poultry, eggs, milk, fruit and vegetables."**

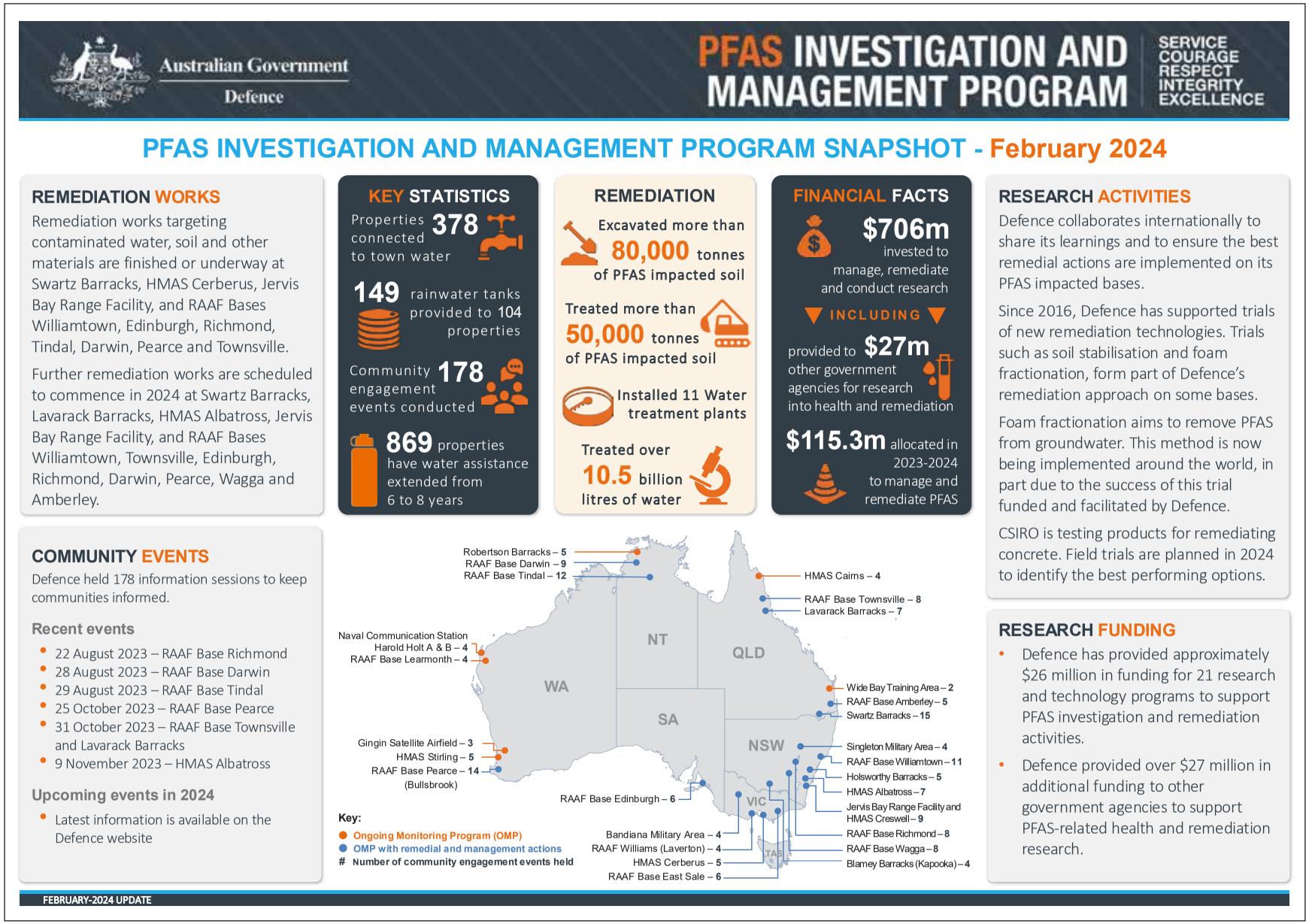
The Independent Reviewer observes that Defence continues to take a strong national leadership role in the investigation and remediation of PFAS contamination, and engagement with impacted communities. The snapshot provided by Defence at Figure 4 demonstrates the progress of Defence's PFAS Investigation and Management Program. The Independent Reviewer acknowledges that Defence has taken a forward-leaning approach, particularly in the absence of effective coordination across all levels of government. More effective national coordination is needed to ensure the response provided around these three sites is appropriately calibrated.

Since financial year 2015/ 2016, Defence has invested more than $700 million to manage the impacts of PFAS contamination, excluding costs associated with legal claims.

10 Department of Defence, *PFAS Investigation and Management Program*, Defence website. https://www.defence.gov.au/about/locations-property/pfas

11 New South Wales Environment Protection Authority (NSW EPA). *Advice to minimise exposure to PFAS*, NSW EPA website, 2021. https://www.epa.nsw.gov.au/working-together/community-engagement/updates-on-issues/raaf-williamtown-contamination/williamtown-precautionary-advice

Figure 4: Defence PFAS Investigation and Management Program snapshot - February 2024



PFAS contamination at Commonwealth-owned and leased airports

The Review is expected to have implications for other Commonwealth sites, including leased federal airports. PFAS-containing firefighting foams were used in Commonwealth aviation firefighting activities at some civilian airports from the 1950s through to 2010. The scale of PFAS contamination across civilian airports is not yet known, nor is the potential scale of any offsite contamination.

There are 21 leased federal airports, which are owned by the Commonwealth and which have been leased on a long-term basis to Airport Lessee Companies. Under the terms of their head lease agreements, Airport Lessee Companies are responsible for environmental management at the airport sites. Airport Lessee Companies and airport tenants also have a range of statutory obligations relating to environmental protection under the *Airports Act 1996* (the Act) and *Airports (Environment Protection) Regulations 1997* (the Regulations). This regulatory framework applies to the management of most environmental issues on-airport, including air, soil, water and noise pollution. Commonwealth-owned airports and aspects of environmental management (e.g. waste management) that are not covered by the Act and the Regulations are enforced by the relevant state/ territory authority, or are managed by the Department of Defence.

The Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA) is delivering a national PFAS Airports Investigation Program at up to 37 airports where the Commonwealth has historically provided firefighting services with PFAS-containing foams. The Program will ensure thorough, independent and targeted testing is undertaken across entire airport sites and migration pathways from airports, which may potentially impact neighbouring residential land. Remediation is out of scope for the Program, with the exception of interim measures to address immediate or extremely high risks. Airport participation in the Program is voluntary. The Program is expected to be completed by 30 June 2027.

Of the 37 airports:

- 20 are leased federal airports, owned by the Commonwealth and leased to Airport Lessee Companies to operate under long-term agreements administered by DITRDCA. Two of these (Darwin, Northern Territory and Townsville, Queensland) are joint-user airports, with both civilian and defence activities on the airport site
- One (Avalon, Victoria) is owned and leased out by Defence
- 16 are 'non-federally leased' and either owned privately or by local governments. These airports are regulated by the relevant state/ territory government. The Commonwealth has no direct role in the ownership, operation, or regulation of these airports.

DITRDCA advises that in contrast to Defence sites, the Commonwealth is less likely to be the sole polluter at civilian airports. Airports are complex industrial sites with multiple tenants. This, and the presence of former landfill sites, migration of PFAS from surrounding urban or industrial areas, and new development that disturbs contaminated soil, can contribute to contamination on and from airports. Further, while Defence is generally the sole owner, operator and historic polluter on Defence bases, civilian airport sites each have their own unique combination of stakeholder roles and responsibilities. This results in a higher level of uncertainty, lower levels of Commonwealth influence, and more complex and nuanced stakeholder roles at civilian airport sites.

The Independent Reviewer acknowledges the importance of the PFAS Airports Investigation Program in understanding the nature and extent of PFAS contamination on and around Commonwealth-owned and leased airports. The Program is being conducted in accordance with relevant national guidance and in consultation with state/ territory authorities.

National guidance for responding to PFAS contamination

Defence applies national guidance to understand and respond to PFAS contamination.

In 2023, the Australian Government committed to establishing Environment Protection Australia as a separate statutory Commonwealth entity to enforce national environmental laws. It will ensure that states, territories and other Commonwealth decision makers apply National Environmental Standards under accredited arrangements.[12]

The Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination is an agreement between the Commonwealth and the states/ territories to respond consistently to PFAS contamination to protect the environment and, as a precaution, protect human health. It seeks to ensure actions are effective, implementable, financially and logistically sustainable, proportionate to risk, and support economic stability. Australia's environment ministers oversee its operation.[13]

The PFAS National Environmental Management Plan (NEMP) establishes a practical basis for nationally consistent environmental guidance and standards for managing PFAS contamination.[14] The plan was developed by all Australian jurisdictions and New Zealand. It recognises the need for implementation of best practice regulation through individual jurisdictional mechanisms. It provides guidance for the investigation and management of PFAS. Version 3 of the PFAS NEMP was open for public consultation between September 2022 and February 2023, and is expected to be released in 2024.

The *National Environment Protection (Assessment of Site Contamination) Measure 1999* seeks to establish a nationally consistent approach to the assessment of site contamination to ensure sound environmental management practices by the community, which includes regulators, site assessors, environmental auditors, landowners, developers and industry. It also seeks to provide adequate protection of human health and the environment, where site contamination has occurred, through the development of an efficient and effective national approach to the assessment of site contamination.[15]

The Independent Reviewer acknowledges that there is a range of work underway across Commonwealth and state/ territory governments, and internationally, that will inform and enhance the national response to PFAS contamination into the future. However, impacted communities do not necessarily have visibility of this work or related progress, which contributes to frustration about the support and advice provided by governments.

12 Department of Climate Change, Energy, the Environment and Water (DCCEEW), *EPBC Act reform*, DCCEEW website, 2024. https://www.dcceew.gov.au/environment/epbc/epbc-act-reform#toc_2>.

13 Council of Australian Governments (COAG), *Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination*, Federation website, 2020.

14 Department of Climate Change, Energy, the Environment and Water, Heads of EPAs Australia and New Zealand, *PFAS National Environmental Management Plan Version 2.0*.

15 Department of Climate Change, Energy, the Environment and Water, National Environment Protection Council, *National Environment Protection (Assessment of Site Contamination) Measure 1999,* latest version 2013.

Industrial Chemicals Environmental Management Standard (IChEMS)[16]

Following the release of the National PFAS Position Statement in May 2020, multiple industries are now working to phase out PFAS use.[17] National reforms to environmental management regulations are well progressed. Commonwealth legislation to establish Industrial Chemicals Environmental Management Standard (IChEMS) came into effect in March 2021. Regulatory scheduling decisions under the IChEMS started in late 2022, with perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorohexane sulfonate (PFHxS) scheduled in 2023. Each jurisdiction is responsible for implementing IChEMS within their own regulatory frameworks. The Department of Climate Change, Energy, the Environment and Water is developing legislation that will impose obligations within the Commonwealth to comply with any IChEMS scheduling decision, including prohibitions or restrictions.

Once fully implemented, IChEMS will enable Australia to meet obligations under the Stockholm Convention on Persistent Organic Pollutants in relation to listings of PFOS, PFOA and PFHxS, and any other PFAS listed.[18]

Human health and exposure to PFAS

All responses to PFAS contamination, including precautionary advice that seeks to reduce exposure, is informed by advice on the human health risks. The Australian Government Department of Health and Aged Care and interim Australian Centre for Disease Control provide high-level national guidance on PFAS. Relevant state/ territory agencies manage site-specific information and provide assessments to residents.

In 2016, the Environmental Health Standing Committee (enHealth), which advises the Australian Health Protection Principal Committee, provided the first public health advice for PFAS in Australia, to assist in responding to contamination at RAAF Base Williamtown and Swartz Barracks.[19] In 2019, enHealth updated its Guidance Statements on PFAS, following an independent review of epidemiological and toxicological evidence for human exposure by an Expert Health Panel commissioned by the then Department of Health.[20] The most recent enHealth Guidance was released in February 2024.[21]

An important contributor to the lack of community confidence in the health advice is that authorities are perceived to base their advice on evidence that is dated and incomplete. Community consultation reflected a level of concern that the advice does not consider the current state of knowledge regarding health impacts of exposure to PFAS. The level of detail in the 2024 enHealth Guidance Statement is unlikely to increase confidence in the advice. An update to the work of the Expert Health Panel, with its detailed analysis of research and evidence, is more likely to address community concerns. Given the importance of health advice, it seems incongruous that the work of the Expert Health Panel has not been updated for five years — particularly considering the evolving national and international understanding of PFAS issues.

Many property owners around the three bases are concerned about the physical and mental health impacts of PFAS contamination. In Australia, outside of occupational settings, exposure to PFAS can occur from the air, indoor dust, food, water and various consumer products.

16 Department of Climate Change, Energy, the Environment and Water, *Industrial Chemicals Environment Management (Register) Amendment (2023 Measures No. 1) Instrument 2023.*

17 Council of Australian Governments (COAG), *Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination, Appendix D: National PFAS Position Statement*, Federation website, 2020.

18 *United Nations Environment Programme, Stockholm Convention, Overview, United Nations Environment Programme website. https://www.pops.int/TheConvention/Overview/tabid/3351/Default.aspx*

19 Department of Health and Aged Care, *Australian Health Protection Principal Committee (AHPPC)*, Department of Health and Aged Care website, 2023. https://www.health.gov.au/committees-and-groups/australian-health-protection-principal-committee-ahppc

20 Environmental Health Standing Committee (enHealth) of the Australian Health Protection Principal Committee, *enHealth guidance statement – Per- and polyfluoroalkyl substances (PFAS)*, Department of Health and Aged Care, 2019. Analysis & Policy Observatory, *Expert health panel for Per- and Poly-fluoroalkyl substances (PFAS): final report*, Department of Health, 2018.

21 Environmental Health Standing Committee (enHealth) of the Australian Health Protection Principal Committee, *Per- and polyfluoroalkyl substances (PFAS) - enHealth Guidance Statement*, Department of Health and Aged Care, 2024.

For most people, food is expected to be the primary source of exposure to these chemicals. For communities around the three bases, higher PFAS levels may be found in the surrounding environment and exposure may occur through other means. Human biomonitoring studies using pooled blood serum samples of the Australian population have shown consistent declines in the levels of PFOS, PFOA and PFHxS in the general population over the past two decades. This decline coincides with the reduction in the global production of PFAS and PFAS-containing products, and the subsequent reduction in use of these products in Australia.

PFAS exposure has previously been associated with some biological effects. However, these effects are small and according to the most recent enHealth guidance, are unlikely to be important to health outcomes.[22]

PFAS exposure has been associated with the following effects in some people:

- increased levels of cholesterol in the blood
- increased levels of uric acid in the blood
- reduced kidney function
- alterations in some indicators of immune function
- altered levels of thyroid hormones and sex hormones
- later age for starting menstruation in girls, and earlier menopause
- lower birth weight in babies.

Potential associations between PFAS exposure and increased risk of two uncommon cancers, testicular and kidney cancer, have been reported. Much of the evidence for PFAS health effects relates specifically to PFOA, a type of PFAS that is less common in Australia — largely because Australia has not manufactured PFAS.

However, studies on these cancers remain conflicting and associations have only been observed in high exposure groups such as workers in international factories where PFOA is produced.

Notably, the enHealth Guidance Statements differentiate between associations of adverse health effects and human exposure to PFAS and causation, with conclusions that there was no evidence that PFAS causes human disease.[23] However, the weaknesses in the scientific evidence means that while early indications suggest that PFAS exposure has a minimal impact on human health, other important health effects cannot be definitively ruled out.

In 2016, the then Department of Health commissioned the Australian National University to conduct the PFAS Health Study to investigate PFAS exposure levels and potential health effects in the communities of Williamtown in New South Wales, Oakey in Queensland, and Katherine in the Northern Territory.[24]

Overall, there was clear evidence of elevated blood serum concentrations of PFAS in residents and workers in the PFAS-affected communities, and increased psychological distress. The evidence for other adverse health outcomes was generally limited. The findings were consistent with previous studies that had not conclusively identified causative links between PFAS and adverse health outcomes.

The Australian Government has previously invested $11.7 million through the National Health and Medical Research Council to further increase the understanding of the acute and long-term potential human health effects from exposure to PFAS.[25] Projects under this research program are expected to conclude by 2024-2025.

Legal claims received and resolved

A significant number of litigated and non-litigated PFAS-related claims have arisen from PFAS contamination from various Defence bases around Australia.

Generally, PFAS-related litigated and non-litigated claims have sought damages for alleged diminution in property value, and for inconvenience, distress and vexation. These claims have been made by

22 Environmental Health Standing Committee (enHealth) of the Australian Health Protection Principal Committee, *Per- and polyfluoroalkyl substances (PFAS) - enHealth Guidance Statement*, Department of Health and Aged Care, 2024.
23 Environmental Health Standing Committee (enHealth) of the Australian Health Protection Principal Committee, *Per- and polyfluoroalkyl substances (PFAS) - enHealth Guidance Statement*, Department of Health and Aged Care, 2024.
24 Department of Health and Aged Care, *PFAS Health Study*, report to the Department of Health, National Centre for Epidemiology and Population Health, Australian National University, 2021.
25 National Health and Medical Research Council, *Targeted Call for Research into Per- and Poly- Fluoroalkylated Substances, Funding outcomes*, NHMRC website. https://www.nhmrc.gov.au/funding/targeted-calls-research/per-and-poly-fluoroalkylated-substances

property owners (and occasionally tenants) located within PFAS investigation or management areas around impacted Defence bases. In some instances, claimants may have also sought damages for alleged economic or business-related losses.

Defence advises that as at 30 January 2024, of Defence PFAS-related claims, 239 non-litigated claims and seven litigated claims have settled, including class actions for communities around RAAF Base Williamtown, Swartz Barracks and RAAF Base Tindal. An additional 120 non-litigated and four litigated claims remain outstanding. Where PFAS-related litigated and non-litigated claims have been settled, it has been on the basis that claims for personal injury caused by, or otherwise relating to, exposure to PFAS are excluded.

Issues around legal claims and compensation continue to be a source of concern, angst and dissatisfaction for a number of stakeholders in the three communities. This includes the amount of compensation received through class action processes, that compensation does not address the actual or perceived loss in value of a property, the time taken to process claims, and continuing impacts of PFAS contamination on use of properties. Current and future health impacts associated with exposure to PFAS are also of ongoing concern.

Many stakeholders are unhappy that the Australian taxpayer has been paying for clean-up activities. In the US, thousands of lawsuits have been filed against manufacturers of PFAS, including for costs associated with treatment of contamination in water supplies. The Independent Reviewer considers that it would be prudent for the Australian Government to monitor precedents established by these cases, and their relevance in the Australian context. This might provide an opportunity to recover some of the costs of contamination responses.

Parliamentary inquiries relating to PFAS

Since 2015, three inquiries into PFAS contamination have been conducted by the Australian Parliament:

1. **November 2015:** Contamination of Australia's Defence Force facilities and other Commonwealth, state and territory sites in Australia[26]
   - February 2016: Report - Part A - RAAF Base Williamtown.[27]
   - April 2016: Australian Government response to Part A.[28]
   - May 2016: Report - Part B – Army Aviation Centre Oakey and other Commonwealth, state and territory sites.[29]
2. **May 2018:** Inquiry into the management of PFAS contamination in and around Defence bases[30]
   - November 2018: Report - Inquiry into the management of PFAS contamination in and around Defence bases.[31]
   - February 2020: Australian Government response[32] Note that this response also addressed the Australian Government response to the May 2016 Part B report.
3. **September 2019:** Remediation of PFAS-related impacts ongoing scrutiny and review[33]
   - December 2019: First Report - Inquiry into PFAS remediation in and around

26 Parliament of Australia, *Contamination of Australia's Defence Force facilities and other Commonwealth, state and territory sites in Australia*, Parliament of Australia website, November 2015. https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Foreign_Affairs_Defence_and_Trade/ADF_facilities#:~:text=On%2030%20November%202015%2C%20the,using%20firefighting%20foams%20(Part%20B

27 Foreign Affairs, Defence and Trade References Committee, *Inquiry into firefighting foam contamination Part A - RAAF Base Williamtown,* Parliament of Australia, February 2016.

28 Foreign Affairs, Defence and Trade References Committee, *Australian Government response to the Senate Foreign Affairs, Defence and Trade References Committee report: Inquiry into firefighting foam contamination Part A - RAAF Base Williamtown,* Parliament of Australia, April 2016.

29 Foreign Affairs, Defence and Trade References Committee, *Firefighting foam contamination Part B – Army Aviation Centre Oakey and other Commonwealth, state and territory sites,* Parliament of Australia, May 2016.

30 Parliament of Australia, *Inquiry into the management of per- and polyfluoroalkyl substances (PFAS) contamination in and around Defence bases*, Parliament of Australia website, May 2018. https://www.aph.gov.au/parliamentary_business/committees/joint/foreign_affairs_defence_and_trade/inquiryintopfas

31 Joint Standing Committee on Foreign Affairs, Defence and Trade, *Inquiry into the management of PFAS contamination in and around Defence bases*, Parliament of Australia, November 2018.

32 Department of Agriculture, Water and the Environment, *Government Response, Whole of Australian Government response to the report of the Joint Standing Committee on Foreign Affairs, Defence and Trade Inquiry into the management of per- and polyfluoroalkyl substances (PFAS) contamination in and around Defence bases*, Parliament of Australia, February 2020.

33 Parliament of Australia, *Remediation of PFAS-related impacts ongoing scrutiny and review*, Parliament of Australia website, September 2019. https://www.aph.gov.au/Parliamentary_Business/Committees/Joint/Foreign_Affairs_Defence_and_Trade/PFASRemediation

Defence bases.[34] Note: There were no recommendations from this report.

- August 2020: Second Progress Report - Inquiry into PFAS remediation in and around Defence bases.[35]
- January 2022: Australian Government response.[36]
- March 2022: Report - Inquiry into PFAS remediation in and around Defence bases.[37] Note: the Australian Government is yet to respond to this report.

The Australian Government has progressed many of the recommendations from these inquiries. However, the Independent Reviewer heard that some recommendations from the various inquiry reports remain unresolved. The broad themes of recommendations that are most relevant to land use include:

- the need for coordination across and between governments, and accountability
- acquisition of properties that are no longer fit for purpose due to PFAS contamination, assistance for property owners to relocate, and compensation
- clarification of Defence/ Commonwealth responsibility for contamination of non-Commonwealth land, and the application of state/ territory environmental regulation.

Additionally, the Australian Government is yet to respond to the March 2022 Report of the Inquiry into PFAS remediation in and around Defence bases.[38] Recommendations from that report are:

- Recommendation 1: The Committee recommends the Australian Government expedite the implementation of any recommendations made by this Committee in its reports to date which have been agreed or agreed in principle and which remain outstanding.
- Recommendation 2: The Committee recommends the Australian Government continue to review and adapt its engagement, communication and support to meet the evolving needs of communities affected by PFAS contamination.
- Recommendation 3: The Committee recommends that as part of implementing Recommendation 2, the Australian Government engage the NSW Government to assess the case for re-establishing the community reference group process.
- Recommendation 4: The Committee recommends that the Australian Government produce and publish quarterly updates on the work of Department of Defence, Department of Health and Department of Agriculture, Water and the Environment on PFAS management issues, on the pfas.gov.au website. These updates should detail work completed and new information made available within their respective portfolios in that quarter.
- Recommendation 5: The Committee recommends that the Australian Government work with state and territory governments to produce regular updates on PFAS management issues for publication on the pfas.gov.au website.
- Recommendation 6: The Committee recommends that the Australian Government establish a coordination mechanism with state and territory environment protection authorities (EPAs) to enable information sharing and, where appropriate, access to undertake PFAS-related investigations related to Department of Infrastructure, Transport, Regional Development and Communications (DITRDC) airfields.
- Recommendation 7: The Committee recommends that the Australian Government consider the research, with a view to examining suitable options for a mechanism for people with high levels of PFAS, who are otherwise unable to donate blood or plasma, to make therapeutic donations as an intervention to reduce their levels of PFAS.
- Recommendation 8: The Committee recommends that the Australian Government provide funding for further longitudinal studies on potential adverse health effects for firefighters and members of PFAS-affected communities.

34 Joint Standing Committee on Foreign Affairs, Defence and Trade, *Inquiry into PFAS remediation in and around Defence bases - First report*, Parliament of Australia, December 2019.
35 Joint Standing Committee on Foreign Affairs, Defence and Trade, *Inquiry into PFAS remediation in and around Defence bases - Second progress report*, Parliament of Australia, August 2020.
36 Joint Standing Committee on Foreign Affairs, Defence and Trade, *Government Response, Australian Government response to the Second Progress Report of the Joint Standing Committee on Foreign Affairs, Defence and Trade's inquiry into PFAS remediation in and around Defence bases,* Parliament of Australia, January 2022.
37 Joint Standing Committee on Foreign Affairs, Defence and Trade, *Inquiry into PFAS remediation in and around Defence bases - Final report*, Parliament of Australia, March 2022.
38 Joint Standing Committee on Foreign Affairs, Defence and Trade, *Inquiry into PFAS remediation in and around Defence bases - Final report*, Parliament of Australia, March 2022.

National coordination: Recommendation 1

The impacts of PFAS contamination (including on the environment, human health, food production, and planning and development) are beyond the remit of any single entity. Agencies across all levels of government do not appear to work well together to deliver an effective response to impacted communities. It is often up to communities to identify problems and suggest solutions.

Assessment: Where are we now?

Since PFAS contamination around RAAF Base Williamtown, Swartz Barracks and RAAF Base Tindal was first made public, it has been clear that close cooperation was needed between all levels of government to provide appropriate and timely responses for impacted communities. A holistic response to PFAS contamination around the three bases requires Defence to work closely with other agencies and levels of government, including on matters relating to health, food production, and land zoning and use. In practice, resolving many of these matters has fallen between the cracks across and within governments.

Each of the previous Parliamentary inquiries into PFAS contamination has sought to improve national coordination:

- In 2016, a committee recommended that "Defence and the New South Wales Government examine establishing a joint taskforce to coordinate the response of government agencies..." and "...enable the Department of the Environment to assume a national leadership role..."[39]
- In 2018, a committee recommended that "the Australian Government appoint a Coordinator-General to coordinate the national response..."[40]
- In 2022, a committee recommended that "the Australian Government establish a coordination mechanism with state and territory environment protection authorities (EPAs)..."[41]

PFAS Taskforce

A key Australian Government initiative to drive coordination was the establishment of the PFAS Taskforce in the Department of the Prime Minister and Cabinet in January 2017. In April 2018, the Taskforce was transferred to the environment portfolio. The Taskforce was appointed to provide oversight of the Australian Government's response to PFAS contamination, including:

- leading PFAS Interdepartmental Committee meetings and quarterly meetings of the Environment Protection Authority and First Ministers' Departments PFAS Forum
- developing and maintaining mechanisms to facilitate nationally consistent responses to PFAS contamination, such as the **www.pfas.gov.au** website, the Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination (PFAS IGA) and the National PFAS Position Statement (which is an appendix to the PFAS IGA).[42]

39 Foreign Affairs, Defence and Trade References Committee, *Inquiry into firefighting foam contamination Part A - RAAF Base Williamtown*, Parliament of Australia, February 2016.
40 Joint Standing Committee on Foreign Affairs, Defence and Trade, *Inquiry into the management of PFAS contamination in and around Defence bases*, Parliament of Australia, November 2018.
41 Joint Standing Committee on Foreign Affairs, Defence and Trade, *Inquiry into PFAS remediation in and around Defence bases - Final report*, Parliament of Australia, March 2022.
42 Council of Australian Governments (COAG), *Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination*, Federation website, 2020.

The Independent Reviewer understands that funding for the PFAS Taskforce expired at the end of financial year 2021-2022, and that Commonwealth departments are working to determine the next steps. The PFAS Interdepartmental Committee, which brings together senior officials from relevant Commonwealth departments, has not met since late 2022.

The PFAS Taskforce played an important and constructive role in coordinating the early response to contamination and through the development of the PFAS IGA. However, during consultation the Independent Reviewer came to the view that practical and on-the-ground cooperation and collaboration between governments was insufficient and often ineffective.

This is particularly important given that local government largely controls land planning and zoning outside of Commonwealth land. Local government is not a party to the PFAS IGA, but its contribution in deciding and implementing responses is important. In this respect, some stakeholders consider that local government processes are not sufficiently connected to the actions and decisions of the Commonwealth and state/ territory governments about PFAS contamination and land use. For example, contamination is often not disclosed on property titles, and local strategic plans and land zoning are often dated and may not acknowledge PFAS contamination in local government areas.

Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination (PFAS IGA)[43]

Another key element of national coordination was the PFAS IGA which the Australian Government brought before the Council of Australian Governments in 2017, and which came into effect in February 2018. The agreed objectives of all jurisdictions, as outlined in the PFAS IGA are to:

- effectively respond to PFAS contamination to protect the environment and, as a precaution, protect human health, including immediate responses to identified contamination, and longer-term remediation or management responses
- strengthen national consistency, collaboration and cooperation in responding to PFAS contamination
- ensure actions are effective, implementable, financially and logistically sustainable, proportionate to risk, and support economic stability.

In 2019, a review of the PFAS IGA identified areas for further collaboration. These included the parties working together to reduce or prevent further PFAS contamination, better communication with PFAS-affected communities to increase awareness of government actions and improve trust, and increased clarity about the roles and responsibilities of polluters and regulators. The PFAS IGA was subsequently updated in 2020.

The PFAS Taskforce has previously convened workshops with Commonwealth and state/ territory agencies to develop and promote the principles of the PFAS IGA. These national workshops reviewed the implementation of the PFAS IGA, and sought to identify other ways to improve national cooperation. The Department of Climate Change, Energy, the Environment and Water advises that governments are currently reviewing the PFAS IGA, focussing on progress made by the parties in achieving its objectives. That review will be considered alongside broader work currently being undertaken on the prevention and management of contamination in Commonwealth areas through the establishment of Environment Protection Australia.

The PFAS IGA includes:

- Appendix A: PFAS Contamination Response Protocol — a tool to help governments work together to respond rapidly, effectively and consistently to PFAS contamination; outlines information about government roles and processes; and provides clear information to communities and industry on what they can expect from governments.
- Appendix B: PFAS National Environmental Management Plan — provides nationally agreed guidance on the management of PFAS contamination in the environment, and supports collaborative action on PFAS by all governments. The plan is adopted by all jurisdictions through their respective contamination management frameworks.
- Appendix C: PFAS Information Sharing, Communication and Engagement Guidelines — supports government agencies to communicate and engage with stakeholders and each other about PFAS management pertaining to their responsibilities.
- Appendix D: National PFAS Position Statement — outlines a nationally unified vision for reducing future PFAS use in Australia, so that governments and PFAS users (whether industry, businesses, manufacturers, regulators, or policy-makers) can work towards an agreed and clear set of objectives.

43 Council of Australian Governments (COAG), *Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination*, Federation website, 2020.

- Appendix E: Health Based Guidance Values for PFAS — aim to protect the general community from exposure to PFAS from food, drinking water and recreational water.
- Appendix F: Environmental Health Standing Committee Guidance Statements on PFAS — guidance statements on key health issues to support jurisdictional responses, recognising the difficulty in assessing and communicating the risks posed by PFAS.
- Appendix G: Australian Health Protection Principal Committee PFAS Factsheet — (This factsheet is no longer available on the Department of Health and Aged Care website. All relevant information has been updated and consolidated within the February 2024 enHealth PFAS Guidance Statement).
- Appendix H: Food Regulation Standing Committee Statement on PFAS and the general food supply — outlines outcomes of a hazard assessment of perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS); and outcomes of a dietary exposure assessment, literature review and the 24th Australian Total Diet Study conducted by Food Standards Australia New Zealand.

During consultation the Independent Reviewer was told that there was still inadequate and insufficient coordination between Commonwealth, state/ territory and local governments to respond to PFAS contamination consistently, or in a manner readily understood by impacted communities. This view was shared by many who were consulted, including state/ territory regulators themselves. In a number of respects, the response to PFAS contamination has highlighted deficiencies in coordination and collaboration across governments. Community representatives have expressed extreme frustration with the inability of Defence and all levels of government to work together to address community needs and concerns, and noted that PFAS contamination is 'a government problem, not a Defence problem'. The Independent Reviewer notes that Defence continues to take the lead in responding to PFAS contamination around these three sites, although other agencies have clear roles and responsibilities.

Some state/ territory authorities reiterated the importance of the 'polluter pays' principle, where a polluting party will generally be responsible for identification and investigation of sites, assessment of risks, engagement with stakeholders, and management and remediation of the affected land. Some jurisdictions have incurred significant costs as part of the national response to PFAS contamination, including in supporting the response for the three Defence sites.

Consultation and submissions from this Review reveal that more clarity is needed for communities to define the role and functions of Commonwealth, state/ territory and local governments for policy development and implementation related to agricultural production for domestic and export markets, food safety, environmental standards and regulation, and health policy, services and advice.

Feedback: Where do we want to be?

There is an urgent need to deliver the integrated, effective national coordination that these communities need to support ongoing land use, including Indigenous communities. Lived experience indicates that existing approaches have not delivered the right results.

The Independent Reviewer notes efforts by governments to enhance collaboration and coordination in other areas, including for example the agreement through National Cabinet to develop a framework and guidance on agreed principles for natural disaster and climate risk considerations in land use planning decisions.[44]

A national coordinating body

A national coordinating body (see Figure 5) should be established to integrate, but not replicate, the work of existing entities across governments that support the response to PFAS management. It would not alter the existing responsibilities of different levels of government but must work to bridge gaps between these levels of government, including in relation to how PFAS impacts the environment, health, agriculture and land use planning and development. The national coordinating body should coordinate the PFAS response, including to drive progress on support for land use change and precinct planning around these three bases.

PFAS contamination in Australia has typically been managed through the lens of environmental contamination. However, impacted communities often view PFAS contamination through the lens of potential human health impacts. Managing PFAS contamination as a health issue would likely see quite different considerations about how communities are supported.

Within a national coordinating body construct, the national response to PFAS contamination will continue to be dominated by considerations of impacts on human health and the environment - this requires the Department of Climate Change, Energy, the Environment and Water, and the Department of Health and Aged Care to play leading roles. In the context of land uses and precinct development, the Department of Infrastructure, Transport, Regional Development, Communication and the Arts has an important role to play. Defence will continue to have an important role on and around Defence sites.

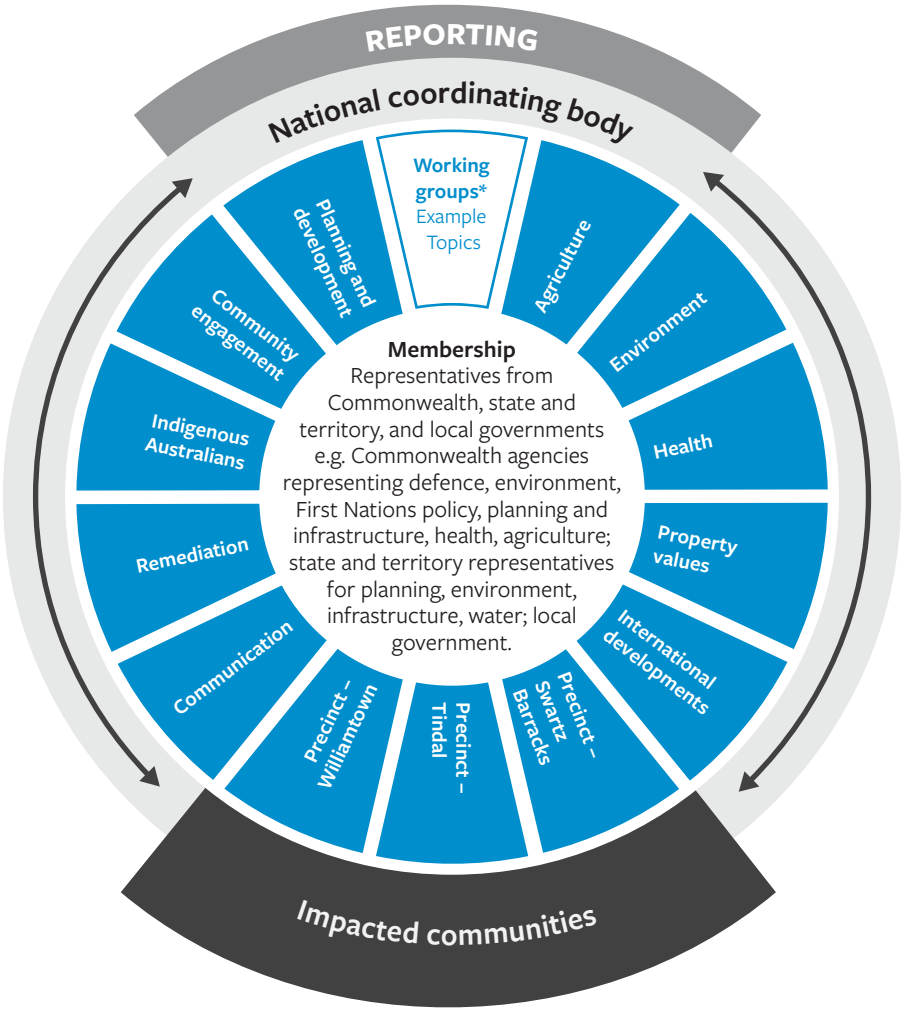
While the Independent Reviewer has not sought to specifically define a model for enhanced national coordination, he was particularly encouraged by the example of the National Coordination Mechanism implemented to address the impacts of COVID-19.[45] The Mechanism is now being embedded as a permanent response tool in the Australian Government Crisis Management Framework and brings together relevant representatives of both government and non-government organisations to coordinate, communicate and collaborate during responses to crisis. The National Coordination Mechanism facilitates rapid problem definition, shared situational awareness and ensures ownership of solutions. It takes a sector-based approach to stakeholder engagement, convening collaborative forums as required to address the specific impacts of a national crisis. The Mechanism ensures coordination, communication and collaboration, but is not a mechanism for command and control. The Mechanism seeks to:

- ensure national leadership and the maintenance of public trust
- ensure that actions are synchronised, coordinated, and responsive
- ensure that any issue or problem is clearly defined and understood
- maintain key functions within communities
- strengthen the ability of the community, economy, and affected individuals to remain resilient and assist their own recovery
- reduce harm and the overall severity of the crisis.

Although the crisis response nature of the National Coordination Mechanism has a very specific context, its features address key gaps in the current national response to PFAS contamination.

44 National Cabinet, *National Cabinet's priorities*, Federation website. https://federation.gov.au/national-cabinet

45 Department of the Prime Minister and Cabinet, *Australian Government Crisis Management Framework* (*AGCMF*), Commonwealth of Australia, 2023.



*Working groups (location-based or thematic)
Working groups would be convened as required to address specific location or thematic topics. They would comprise representatives from the national coordinating body, industry, business, Traditional Owners and communities.

Figure 5: Indicative structure for a national coordinating body

Enhanced national coordination will facilitate an organic platform for integrated Commonwealth, state/ territory and local government responses to PFAS contamination. This includes contamination arising from the historic use of legacy firefighting foams, broader issues such as PFAS contamination in waste streams and biosolids, and potentially future (non-PFAS) contamination issues.

The national coordinating body would provide national and strategic guidance and promote consistency. It could achieve outcomes at a jurisdiction or site level through location-based working groups, or focus on topics such as health and food production through thematic working groups. This would help to ensure that all levels of government and communities, including Indigenous communities and industry, have an opportunity to contribute to solutions.

Progressing the planning, design and development of a social, economic and natural capital precinct (see Recommendation 17) around RAAF Base Williamtown would be a good example of a priority that could be progressed through a working group under the national coordinating body.

There is also opportunity to explore how the polluter pays principle should operate in practice, particularly where significant costs may arise to manage or remediate contamination across large areas of land and in multiple jurisdictions.

Terms of Reference and objectives for the national coordinating body and working groups

should be developed through co-design with community, Indigenous communities and industry representatives.

Enhanced national coordination relies on clear accountabilities for delivery of outcomes. There should be annual public reporting to the Australian Government to demonstrate progress and accountability. Implementation will rely on appropriate resourcing of the national coordinating body and working groups.

The Independent Reviewer acknowledges there will be a cost to government to establish and resource a national coordinating body, and to implement recommendations from this report. However, over time these costs are likely to be somewhat offset, including against benefits of an enhanced and streamlined national response to PFAS, and clarity around remediation.

A new approach to enhanced national coordination would provide a framework to support impacted communities immediately. It would enable future policy developments to be managed, including if health advice or other guidance were to change. While contamination responses to date have addressed a broad range of stakeholder concerns, impacts on current and future land uses continue to be of concern to property owners and other stakeholders.

The Independent Reviewer considers that governments and communities would benefit from greater efforts to align the processes for managing PFAS contamination with the established processes applied to the management of risk for other chemicals of concern. This will allow a more integrated and efficient approach to the management of all known contamination in areas surrounding these bases, including processes to adjust management with new information about PFAS risks to existing land uses or health.

Addressing the gap between 'where we are now' and 'where we want to be'

Recommendation 1: That the Australian Government take immediate action to strengthen coordination and integration of the response to PFAS contamination across and between the Commonwealth, state/ territory and local governments.

Actions to implement

- As a priority, the Australian Government should establish a national coordinating body with representation from Commonwealth agencies with key policy responsibilities informing the response to PFAS contamination, and from state/ territory and local governments.
- The national coordinating body and working groups should develop Terms of Reference and objectives to guide their work. These should be developed through co-design with community, Indigenous communities and industry representatives.
- The national coordinating body should establish location-based and thematic working groups to drive progress on priority issues. Such working groups should include representation from relevant Commonwealth, state/ territory and local governments, and should engage with local communities, Indigenous communities and industry representatives.
- The Australian Government should ensure the national coordinating body is appropriately resourced. The national coordinating body should explore opportunities to more effectively and efficiently achieve whole-of-government outcomes, noting that there is already significant expenditure in responding to PFAS contamination across Commonwealth agencies and state/ territory governments. Potential legal actions by the Commonwealth against manufacturers of PFAS might provide an opportunity to recover some of the costs of contamination responses into the future.
- The national coordinating body should ensure transparency and accountability of outcomes for impacted communities, and for delivery of relevant recommendations in this Review, through annual public reporting to the Australian Government.

Access to information: Recommendations 2-4

Communities are concerned about the currency and accuracy of advice from Australian governments about PFAS contamination. They want credible, relevant, and up-to-date information that they can trust. They want information to be in plain English so they can understand what contamination means for them and for their individual circumstances and land uses. They want to know what they can do with their land, not just what they cannot do with their land.

Assessment: Where are we now?

An enormous amount of information about PFAS is available, including in relation to health impacts, remediation and management, and the behaviour of PFAS in the environment. Information is available from a wide range of sources, including government agencies, non-government organisations, academia, industry, and mainstream and social media. This makes it more difficult for impacted communities and other stakeholders to identify credible and reliable sources, and to identify information they can reasonably apply to their individual circumstances. The lack of trusted, plain English information exacerbates community uncertainty and anxiety, and can contribute to distrust of information from governments.

Defence advice to PFAS-impacted communities

As of February 2024, Defence has conducted 178 community engagement events through the PFAS Investigation and Management Program. In recent years, the focus of this engagement has evolved from advising communities on the results of investigations and risk assessments, to providing updates on the status of PFAS remediation and the results of recent monitoring. Numerous stakeholders told the Independent Reviewer that there are opportunities for Defence to improve how it provides advice to communities, and the nature of that advice. Landowners and residents want clear and reliable advice about PFAS contamination and remediation that is relevant to their specific circumstances, informs them about risk, and provides realistic options for them to reduce their exposure to PFAS. This includes Indigenous communities that want culturally-appropriate and tailored advice about the environmental and health impacts of PFAS to Country that is significant to them. For example, the Independent Reviewer was told about areas near RAAF Base Tindal that contain cultural heritage sites and are associated with songlines, and heard of offers to work with Defence to provide training in understanding and respecting culture.

Property owners and residents also want genuine whole-of-government engagement, so that issues raised by them are addressed in a timely manner and are not passed from one agency to another without resolution. Consultation with community stakeholders revealed that during community events Defence is often asked to respond to issues that other agencies have policy responsibility for, such as the appropriateness of environmental guidance and standards, interpretation of research into health impacts, and processes and procedures to be followed by primary producers. Agencies with policy responsibility for issues from Commonwealth, state/ territory or local governments may not participate at these community events. While many agencies have high-level guidance and talking points on issues, these are often not sufficient for property owners to apply to their individual circumstances.

Some community members noted that Defence had previously employed locally-based Community Liaison Officers in these three communities who had focussed on building relationships with the community and providing advice. These officers undertook site-based frontline engagement and were able to engage with the community in a relational manner, visit properties, answer questions, discuss sampling results, and source additional technical or policy advice. They were also able to link community members to available services, and work across all levels of government to assist in addressing issues.

Traditional Owners were invited to represent Indigenous communities at separate, face-to-face sessions with the Independent Reviewer in each of the three communities. Feedback indicated that Indigenous Australians across the three communities had varying levels of understanding about PFAS exposure. The Independent Reviewer has identified that Defence should place greater emphasis on engaging with Indigenous communities as a unique stakeholder group, and work with Traditional Owners to develop and share advice. This previous lack of focus on engagement with Traditional Owners may have contributed to reduced engagement by Traditional Owners in this Review.

The Independent Reviewer did observe that the Worimi Traditional Owners of land surrounding RAAF Base Williamtown had a considerable awareness of PFAS issues. This may reflect the strong relationship the Independent Reviewer observed between the Traditional Owners and the local Defence Indigenous Liaison Officer.

Whole-of-government advice

Stakeholders held conflicting views about the state of knowledge of potential health impacts of PFAS exposure, the ability to use land for food production, and the prospects for remediation of PFAS contamination. The Independent Reviewer considers that the relevance of PFAS issues reported in the media, particularly in relation to how PFAS contamination is managed and regulated overseas, was not satisfactorily communicated to the public, impacted communities and industry. While acknowledging the importance of a precautionary approach, communication about PFAS contamination appears to generate a degree of fear and misunderstanding. One stakeholder expressed a desire for "science to win over emotion". Many stakeholders believe that more stringent policy guidance and frameworks will continue to be developed, and this reduces their confidence in current advice and policy guidance.

A key element of the Australian Government's approach to providing information on PFAS is through the online 'Australian information portal' for PFAS at www.pfas.gov.au (the PFAS website). The PFAS website is maintained by the Department of Climate Change, Energy, the Environment and Water and provides information and links to other Commonwealth and state/ territory government websites and information. The PFAS website includes advice across the spectrum of PFAS impacts, as well as government responses, policy guidance and research.

Some information and advice on the PFAS website is outdated, and other information is not complete or comprehensive. In instances where information is not recent or date stamped, there is no way for stakeholders to know whether the information remains current or not. The PFAS website provides limited information about work currently underway across government to assess existing positions, advice or support. This leaves affected communities wondering whether governments are taking any current action to address PFAS issues, and whether national and global developments are being considered or addressed. There is limited acknowledgement of, or commentary about, why Australian positions relating to PFAS may differ from other international positions, particularly in the United States or Europe.

The Independent Reviewer notes that the Defence PFAS Investigation and Management Program website appears to be current and regularly updated.[46]

Concerns about potential health impacts are often most pressing to property owners in PFAS management areas around the three sites. Health advice about exposure to PFAS is linked directly to how community members use their land, and to the precautionary advice that regulators provide about limiting exposure to contamination. The Independent Reviewer found a very high level of concern and angst amongst the three communities about the currency of human health advice provided by governments. There is also concern that Australian guidance typically refers only to three PFAS compounds (perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS)), and it is not clear to impacted communities why guidance is not provided for other PFAS compounds. Many community members told the Independent

46 Department of Defence, *PFAS Investigation and Management Program*, Defence website. https://www.defence.gov.au/about/locations-property/pfas

Reviewer that they were aware of credible research and publications related to health impacts that they believed had not been considered or addressed by Australian authorities.

Most national level health guidance refers communities to state/ territory health authorities for community and site-level health advice. The Independent Reviewer heard that in many circumstances, the value of this advice is diminished as state/ territory health authorities rely heavily on the national health advice regarding broad exposure scenarios. This makes it challenging for property owners to apply the advice to their individual circumstances.

During consultations for this Review, a number of community members called for government-funded blood testing to be provided for impacted communities, even if only to give individuals information about how much PFAS was in their blood. Some community members also felt that having information about their PFAS levels now was important should PFAS be found to cause disease or illness in the future. The Independent Reviewer notes that a program of blood testing previously provided by the Australian Government ended in 2019, and was conducted in the context of the PFAS Health Study.[47]

A number of community members also wanted longitudinal studies to be conducted to enable potential future health impacts to be monitored. Some community members also sought the establishment of a fund to address potential future health impacts, to be used if a causal link between exposure to PFAS and health impacts was established in the future.

The updated PFAS enHealth Guidance Statement, released in February 2024, indicates that "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. Levels of concern can vary between individuals and for some it can add to the mental health burdens they may already be carrying. PFAS contamination can have a range of consequences for those affected including impacts on property values, produce, income, reputation and risks to health. Addressing concerns can therefore have a positive impact on wellbeing."[48]

Some stakeholders indicated that simple references to "mental health impacts" of PFAS contamination significantly understated the extent to which local communities have been affected. The Independent Reviewer observed the distress and ongoing mental health impacts of PFAS contamination in these communities during public hearings, focus groups and through submissions. This included apprehension regarding the 'unknown' relating to exposure to PFAS. Some community members described having "worries about worries", and concerns about whether routine activities in their daily lives were safe.

The Independent Reviewer noted that while some community members had accessed mental health services to address the impacts of PFAS contamination, others wanted the root cause (remediation of PFAS contamination) addressed, rather than symptoms being treated.

The Independent Reviewer notes advice in the current enHealth Guidance statement that "Assistance should be tailored to the circumstances and include the full range of mental health and wellbeing supports available. Individuals can access mental health support through a range of face-to-face, digital and enquiry services. The Australian Government Department of Health and Aged Care publishes information on the mental health supports available on its website".[49]

47 Department of Health and Aged Care, *PFAS Health Study*, report to the Department of Health, National Centre for Epidemiology and Population Health, Australian National University, 2021.

48 Environmental Health Standing Committee (enHealth) of the Australian Health Protection Principal Committee, *Per- and polyfluoroalkyl substances (PFAS) - enHealth Guidance Statement*, Department of Health and Aged Care, 2024.

49 Environmental Health Standing Committee (enHealth) of the Australian Health Protection Principal Committee, *Per- and polyfluoroalkyl substances (PFAS) - enHealth Guidance Statement*, Department of Health and Aged Care, 2024.

Feedback: Where do we want to be?

Communities need clear, consistent advice about what PFAS contamination means for their situation and circumstances, including how they can use their land. They need advice from credible sources that they trust. Confidence in the advice provided by governments can be improved through greater transparency, ensuring the currency of advice, and explaining why positions are taken. Agencies with policy responsibility for relevant issues need to be proactive in assessing information and developments, providing advice, and engaging with impacted communities and other stakeholders. Engaging communities, and identifying and addressing impacts of PFAS contamination, are not solely Defence responsibilities. Relevant Commonwealth and state/ territory agencies should continue to address issues for which they have accountability for policy or delivery. This should occur in close consultation with local governments, to ensure advice is applied to the circumstances of local communities. Establishing a national coordinating body would help facilitate these joined-up approaches.

Updating PFAS advice

A national coordinating body would help ensure that key elements of national PFAS guidance and advice are fit-for-purpose, and regularly reviewed and published. A wide range of national advice and guidance directly or indirectly affects decisions around land use, and would benefit from plain English updates — key elements are detailed as 'Actions to implement' below. Progress and outcomes of research programs need to be published, and regular updates are required about the need for further research. Core information and guidance from all agencies should be available on a fit-for-purpose PFAS website.

There would be benefit in the national coordinating body publishing an annual work program to assist in communicating and building social capital with impacted communities. As a priority, health advice on impacts of exposure to PFAS should be updated, as should guidance on food production for property owners, primary producers and exporters. Developing advice on the status of PFAS remediation technologies, and prospects for remediation, is also critical. This advice should include issues such as maturity, scalability and sustainability, and remediation of broad-scale, low-level PFAS contamination.

PFAS Rapid Review

The Independent Reviewer considered that it was critical to have a basis on which to assess the current state of knowledge about potential health impacts of exposure to PFAS. The Review Secretariat engaged the Australian National University to undertake a 'PFAS Rapid Review' (Attachment C). The Rapid Review had two primary objectives:

- to outline and compare the public health advice on PFAS in Australia, the European Union and the United States, including the context of exposure to PFAS in each location, and to discuss the key epidemiological evidence published in the past five years, with a focus on high-quality evidence from systematic reviews
- to outline and compare the human Health Based Guidance Values (HBGV) for PFAS in Australia, the European Union and the United States, including the methodology used to derive them, the key numbers such as the Tolerable Daily Intake or equivalents, and critical health endpoints used in each region.

The outcomes of the Rapid Review inform the recommendations of this Review. The Rapid Review: "identified 99 reviews, including systematic reviews, meta-analyses, and scoping reviews, published in the past five years that reported on the evidence of human health effects associated with PFAS. ...many of them represent a re-evaluation of previous key or pivotal studies. They do not necessarily represent significant advances in the scientific evidence base around PFAS and health effects."

"In Australia, Food Standards Australia New Zealand (FSANZ) developed the HBGV for PFAS using data from animal studies for toxic endpoints. ... This methodology is considered a sound approach in the absence of appropriate high-quality human studies. ...In contrast, both the United States Environmental Protection Agency (USEPA) and European Food Safety Agency (EFSA) used human epidemiological studies to establish endpoints on which to base their HBGV. ... This approach has resulted in significantly lower values for PFAS HBGV compared to those established in Australia and elsewhere. ...The use of observational human epidemiological studies presents several limitations including difficulties in clearly defining an exposure, the possibility of confounding, and an inability to demonstrate causality. In its report on PFAS HBGV in 2017, and its subsequent review of the evidence

around PFAS and immunotoxicity in 2021, FSANZ considered that it was inappropriate to base PFAS HBGV on the available human epidemiological studies that looked at immune effects."

The Independent Reviewer acknowledges that an updated PFAS enHealth Guidance Statement was released in February 2024. However, the results of the Rapid Review undertaken by the Australian National University demonstrate that a comprehensive review of work of the PFAS Expert Health Panel published in May 2018 is required.

The Independent Reviewer understands that the National Health and Medical Research Council is reviewing the Australian Drinking Water Guidelines[50], and this is expected to be completed in early 2025.

Blood testing

The Independent Reviewer accepts advice from enHealth and Australian health authorities, and commentary in the ANU's Rapid Review, that individual blood testing does not inform clinical management related to PFAS exposure and is not supported. Blood tests measuring levels of PFAS do not provide the evidence required for a medical practitioner to be able to tell a person whether PFAS levels found in their blood will cause health problems, or if any current health problems are related to those levels.

Increasing Australia's evidence base for PFAS health advice

While PFAS blood testing is not supported, the Independent Reviewer considers that there is significant benefit in biomonitoring programs that support the collection of long-term data, which will help establish baseline PFAS levels in the Australian population. For example, PFAS biomedical testing is part of the Intergenerational Health and Mental Health Study through the National Health Measure Survey, administered by the Australian Bureau of Statistics.[51] The main collection of samples for the study occurred over 2022-23, with the results expected to be released in 2025. This will be the first time data on PFAS has been collected by the Australian Bureau of Statistics and will provide a baseline estimate of PFAS serum concentration levels for the Australian population for use by Commonwealth and state/ territory health and environmental health personnel.

Further advice is required about the:

- need for longitudinal health studies
- information general practitioners can provide to their patients about human health impacts of exposure to PFAS
- need for human health and ecological guidance for PFAS compounds other than perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS)
- developments in international actions to understand and manage health impacts of exposure to PFAS (including through the World Health Organization).[52]

Defence advice to impacted communities

Defence must continue to provide advice to impacted communities in a range of formats, to increase the likelihood these stakeholders have access to an approach that suits them. 'Town-hall' type sessions enable communities to hear a single message about the progress of remediation and outcomes of site-level monitoring. However, property owners also seek advice on the status of PFAS contamination on their land, groundwater and surface water. They want to know what contamination means in the context of how they use their land, the production and consumption of homegrown food, and prospects for remediation of contamination. While precautionary advice is focussed on activities that should not occur, property owners also seek clear advice on activities that can occur on a property and how to manage risks. In consultation with state/ territory authorities, Defence needs to provide clear, concise and plain English interpretations of the results of sampling for individual properties. This approach could be informed by guidance in the enHealth Risk Communication Principles, which also address transparency and relevance.[53] During consultations, stakeholders indicated that visual material that showed their property in the context of PFAS contamination, and information on how levels of contamination and risk related to existing land use, was most useful.

50 National Health and Medical Research Council and National Resource Management Ministerial Council, *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*, Commonwealth of Australia, 2011 (Updated September 2022).

51 Australian Bureau of Statistics (ABS), *Intergenerational Health and Mental Health Study (IHMHS)*, ABS website. https://www.abs.gov.au/about/key-priorities/ihmhs

52 World Health Organization, *Water Sanitation and Health, PFOS and PFOA in Drinking-water: Background document for development of WHO Guidelines for Drinking-water Quality*, 29 November 2023. https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/chemical-hazards-in-drinking-water/per-and-polyfluoroalkyl-substances

53 Department of Health and Aged Care, Environmental Health Standing Committee (enHealth) of the Australian Health Protection Principal Committee, *enHealth guidance – Risk communication principles*, Department of Health and Aged Care website, 2021.

Defence needs to consider re-establishing Community Liaison Officers with a strong relational focus, who would further assist in addressing individual needs of property owners. Their role would be to provide advice to property owners that is informed by local circumstances, link community members to available services, and work across all levels of government.

The national coordinating body should ensure that relevant Commonwealth, state/ territory and local government agencies participate in community engagement events run by Defence, to provide holistic advice and support to the community.

Indigenous communities

As Defence progresses the management and remediation of PFAS contamination at each of the three bases, it needs to work with state/ territory authorities to explore different methods and formats for engaging with Indigenous communities. This engagement should be informed by Australian Government policies and protocols for engagement with Indigenous communities.

Defence needs to invest in supporting engagement with Indigenous communities and provide access to current, relevant and culturally-appropriate information about the impacts of PFAS contamination. Defence should conduct bespoke sampling of culturally significant flora and fauna, and collaborate with Traditional Owners to provide advice on potential impacts of PFAS contamination on cultural practices, and options for mitigating those impacts.

Addressing the gap between 'where we are now' and 'where we want to be'

Recommendation 2: That the national coordinating body enhance the availability of credible, relevant and up-to-date information on impacts of PFAS contamination to assist in addressing community concerns and to enable existing land uses. This includes taking immediate action to update the work undertaken by the PFAS Expert Health Panel which reported in May 2018.

Recommendation 3: That Defence and state/ territory authorities provide information to property owners on impacts of PFAS contamination that considers their individual circumstances.

Recommendation 4: That Defence and state/ territory authorities take early action to improve the availability of culturally-appropriate and tailored advice on impacts of PFAS contamination for Indigenous communities who access and use land surrounding RAAF Base Williamtown, Swartz Barracks and RAAF Base Tindal.

Actions to implement:

- The national coordinating body should review and maintain the content available on **www.pfas.gov.au**.
- The national coordinating body should ensure key public guidance is updated and maintained, including:
  - the work published by the PFAS Expert Health Panel in May 2018
  - the Australian Drinking Water Guidelines (the Independent Reviewer understands this work is underway)
  - the PFAS Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination
  - additional guidance for primary producers to meet national and international standards for PFAS in food (the Independent Reviewer understands this work is underway)
  - an annual status report of technologies for the remediation of PFAS in soil, surface water and groundwater.
- The national coordinating body should ensure advice is provided on:
  - implications for Australia of key developments in international approaches to responding to PFAS, including work underway through the World Health Organization
  - progress in implementing the Industrial Chemicals Environmental Management Standard to meet internationally accepted standards under the Stockholm Convention
  - the status of research previously commissioned by the Australian Government, including grants managed through the Australian Research Council and the National Health and Medical Research Council; and the need for additional research

  - information general practitioners can provide to their patients about human health impacts of exposure to PFAS contamination
  - the need for human health and ecological guidance for PFAS compounds other than perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS).
- Defence should work with the national coordinating body to appoint local Community Liaison Officers for the three sites, to provide advice to property owners that is informed by local circumstances, link community members to available services, and work across all levels of government.
- Defence should continue to work with state/territory authorities to provide PFAS sampling to property owners on request, with plain English advice on what results mean in the context of applicable land uses.
- Defence should conduct environmental PFAS sampling to provide Indigenous communities with an increased understanding of contamination in local soil, surface water, groundwater and biota; and work with state/territory authorities to provide culturally-appropriate information (for example in relevant language) on how the results relate to cultural needs.

Transparency about PFAS management and remediation: Recommendations 5–8

Impacted communities want to understand whether remediation will be effective, and how long it will take. There are unintended consequences from establishing PFAS management areas, including relating to property valuations and financial lending practices. These remain a source of great concern for impacted communities.

Assessment: Where are we now?

Health-based guidance values indicate the amount of a chemical in food or drinking water that a person can consume on a regular basis over a lifetime without any significant risk to health. They are used in site investigations in Australia with the aim of protecting the general community from exposure to PFAS from food, drinking water and recreational water. Health-based guidance values can also be used to assist in assessing human health risk.[54] Risk assessments conducted using the health-based guidance values provide advice on the potential to exceed the tolerable daily intake through consumption of homegrown food, groundwater or surface water. State/ territory regulators use this information to provide precautionary advice for specific property owners in PFAS management areas, or for a PFAS management area or management zones.

PFAS management areas

Defence advises that the definition and application of PFAS management areas (sometimes called monitoring areas) can vary across sites. Generally, management areas represent geographical areas that are subject to PFAS risk management activities, which may include remediation, management and/ or monitoring of PFAS in the environment. Management areas, or zones within an area, may also be defined to assist in managing human health impacts. The management area may align with a base boundary or include surrounding private property.

PFAS management area boundaries are generally established by Defence, based on advice from expert consultants. The Williamtown PFAS Management Area is the only site where a state/ territory authority defined the boundary, and the New South Wales Environment Protection Authority (NSW EPA) continues to manage the area. This unique responsibility and accountability potentially means that the RAAF Base Williamtown PFAS Management Area is administered differently from all other Defence PFAS management areas.

There are some unintended consequences of defined PFAS management areas. For example, the fact that a property is in a PFAS management area does not necessarily give any indication of whether the property is contaminated, or to what level. In addition, the presence of contamination does not necessarily provide any indication of the risk of exposure.

54 Department of Health and Aged Care, *Health Based Guidance Values for PFAS for use in site investigations in Australia*, Department of Health and Aged Care website, 2017.

Many community members are concerned about the impacts of PFAS contamination on property values. This can result from actual contamination, constraints on how land can be used, or proximity to a Defence base. The Independent Reviewer was told of numerous circumstances where (from the property owner's perspective) property valuers significantly undervalued a property or even gave a property a valuation of $0 - sometimes irrespective of actual contamination levels. The Australian Property Institute recognises 'stigma' as an issue in property valuation, including as a result of contamination, and notes that "A stigmatised property is one that buyers or tenants may avoid for reasons not related to its physical condition, features, or use".[55] In other cases, the Independent Reviewer heard that lending practices by financial institutions to property owners in a PFAS management area (or in particular postcodes) resulted in property owners being unable to borrow against the value of their own properties. The Independent Reviewer also heard that prospective buyers of property were not able to borrow money to purchase properties because properties were in a management area.

Precautionary advice issued by state/ territory authorities can include recommendations that groundwater should not be consumed or used. It can also include advice that consumption of homegrown produce such as fruit, vegetables, eggs or meat be limited; and/ or consumption of locally caught fish be limited. Precautionary advice affects the ability of property owners to use their land in accordance with land zoning, and may affect the potential for the highest and best use of land to be realised.

While precautionary advice may not be legally binding, consultation indicates that most property owners adhere to formal advice provided by state/ territory regulatory authorities, particularly as it relates to health. Even so, a number of property owners, particularly those located further from Defence base boundaries, are not convinced that the precautionary advice remains necessary. They are distressed about the impact of precautionary advice and management zones on the value of their property. Some property owners want precautionary advice to be reviewed based on sampling results of contamination, rather than using modelling and a precautionary approach. Consultation also demonstrated a degree of uncertainty and confusion about how precautionary advice for a management area or zone applies to individual properties, and how precautionary advice impacts land use more broadly. Questions raised included whether:

- human health risk assessments remain current
- precautionary advice remains current, or whether the specific areas/ properties to which it applies should change
- assumptions that informed the establishment of management areas remain current
- remediation of PFAS source areas on a Defence site has resulted in any change in the profile of off-base contamination, when any change could be expected, and the likely extent of any change
- a groundwater bore in a management area can be used if sampling indicates low levels of contamination, or no contamination
- properties can be removed from management areas if sampling indicates low levels of contamination, or no contamination
- there is still a need for any 'buffer' in management areas to protect against future movement of PFAS contamination.

The risks presented by exposure to PFAS are difficult to communicate, partly because of the technical nature of risk assessments and of considerations underpinning precautionary advice. There is also concern among property owners about the longevity of precautionary advice, how and when it will be reviewed, and the thresholds or triggers for precautionary advice to be changed or removed.

Williamtown Management Area

Defence advises that PFAS has moved from source areas on the base through surface water and groundwater, and has spread throughout the Williamtown PFAS Management Area. Apart from some areas where PFAS is concentrated offsite, such as south of RAAF Base Williamtown, a substantial portion of the Williamtown Management Area is impacted with low levels of PFAS.

The NSW Government's map of the Williamtown PFAS Management Area is dated December 2017 (refer Figure 1). The NSW Government advises that the boundaries were based on many different sources of information, including the:

- Defence Human Health Risk Assessment monitoring data (December 2017)
- location of drainage lines, creeks and other surface water features

55 The Australian Property Institute, *Contamination Issues – Real Property* [Guidance Paper], 2022, *Contamination Issues ED*, 2022.

- height of land above sea level
- location of property boundaries and roads
- flow of surface water and groundwater based on actual measured data, and modelled data for where contamination may flow in the future.[56]

The Williamtown PFAS Management Area comprises three zones, each of which have tailored precautionary advice for residents to minimise exposure to PFAS:

- Primary Management Zone — this area has significantly higher detected levels of PFAS and therefore, the strongest advice applies.
- Secondary Management Zone — this area has some detected levels of PFAS.
- Broader Management Zone — the topography and hydrology of the area means PFAS detections could occur now and into the future.[57]

The NSW EPA has advised that the precautionary dietary advice provided to the Williamtown community outlines actions property owners may wish to take to limit their exposure to PFAS. The precautionary advice is voluntary and there are no statutory or legal obligations to comply with the advice provided.

Defence has funded infrastructure for 342 properties to connect to Hunter Water Corporation's reticulated water network, where they were previously reliant on groundwater for drinking. Defence is paying bills for water access and usage for 440 properties.

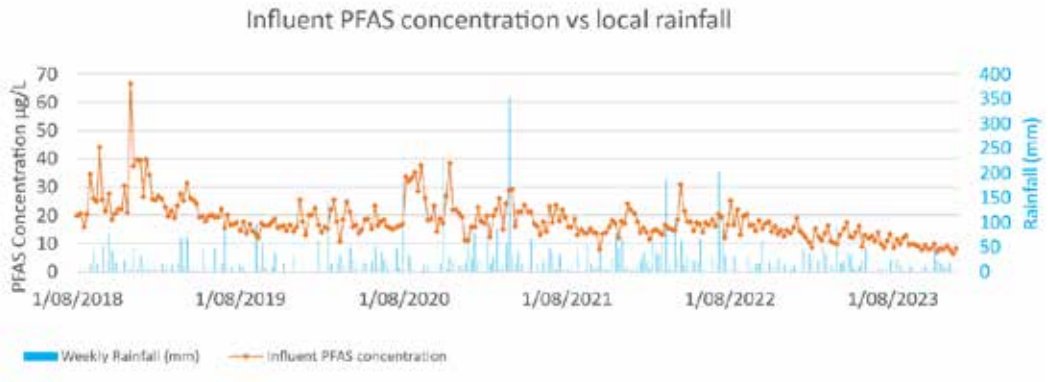
Since 2016, RAAF Base Williamtown has been subject to extensive groundwater remediation. Three water treatment plants continue to operate on the base, and more than 4.6 billion litres of groundwater has been treated. More than 14,000 tonnes of contaminated soil from source areas on base has been removed, including from the fire station area and the former fire training area.

In October 2022, Defence completed a strategy review to assess the effectiveness of remediation actions at RAAF Base Williamtown. The review recommended further remediation, including some off-site groundwater extraction, additional surface water treatment, and more remediation trials to improve the long-term management of groundwater and surface water.[58]

The NSW EPA considers mitigation and remediation to reduce the impacts of PFAS contamination on the affected community and the environment is of the greatest importance. The NSW EPA advised the Independent Reviewer that the Williamtown Management Area and Zones (and the associated precautionary advice) will remain in place until Defence provides scientifically rigorous and consistent evidence to indicate that contamination migrating off-site is reducing and that existing contamination off-site is retracting.

Remediating groundwater is challenging

Defence advises that the graph below shows the concentrations of PFAS in the water being treated at the former fire training area at RAAF Base Williamtown.[59]



56 New South Wales Environment Protection Authority (NSW EPA), *RAAF Base Williamtown PFAS contamination*, NSW EPA website, 2023. https://www.epa.nsw.gov.au/working-together/community-engagement/updates-on-issues/raaf-williamtown-contamination

57 New South Wales Environment Protection Authority (NSW EPA), *RAAF Base Williamtown PFAS contamination*, NSW EPA website, 2023. https://www.epa.nsw.gov.au/working-together/community-engagement/updates-on-issues/raaf-williamtown-contamination

58 Department of Defence, *RAAF Base Williamtown*, Department of Defence website, 2023. https://www.defence.gov.au/about/locations-property/pfas/pfas-management-sites/raaf-base-williamtown

59 ECT2, *Monthly Treatment Dashboard, Williamtown – FFTA (Former Fire Training Area) Water Treatment Plant (WTP)*, RAAF Williamtown, ECT2, 2024.

"The PFAS concentrations are approximately a quarter of what they were when pumping first commenced in 2018, decreasing very gradually over time. If the target is PFAS concentrations less than drinking water guidelines (i.e. less than 0.07 µg/L), then a further decrease of a factor 'x 100' is needed. This is why groundwater remediation timeframes are often measured in decades or longer. This example is for a small source area, on larger scales the challenges and timeframes amplify exponentially."

Oakey Management Area

Defence advises that PFAS has been found across and beyond the base, spread via groundwater and surface water.

Queensland Health has issued general advice about PFAS impacts and risks, which is not specific to Swartz Barracks. This advice states "In areas where contamination of water (e.g. in underground, springs, water bores, dams, ponds or creeks) has been identified, human exposure can be minimised by:

- not drinking the water, or using it to prepare food
- not consuming food products (e.g. eggs, milk, meat, fish, fruit or vegetables) grown or produced using, or in, contaminated water
- avoiding or minimising the use of the water for showering/ bathing, sprinklers or to fill swimming pools or paddling pools due to the possibility of unintentionally drinking the water".[60]

"Defence has provided alternative water to a number of properties that were reliant on groundwater for drinking. This has included connecting 53 properties to Toowoomba Regional Council's reticulated water network, and providing 19 properties with rainwater tanks where those properties could not be connected to the water network. Defence is paying water bills and/ or access charges for 53 properties.

Since 2017, Swartz Barracks has been subject to extensive groundwater remediation. One groundwater treatment plant continues to operate on the base, and more than 430 million litres of groundwater from source areas has been treated. More than 8,900 tonnes of contaminated soil on base has been treated, including from the former fire training area. More than 12,000m^3 of sediment from on-base drains has been removed.

The Queensland Department of Environment, Science and Innovation has advised the Independent Reviewer that removing the precautionary advice that applies to the Oakey Management Area would imply the clean-up has been effective in restoring the protected environmental values. However, it also stated that it was uncertain what future concentrations of PFAS would be acceptable to protect the environment and human health. It further acknowledged that clean-up of the total groundwater resource in the investigation area may not be practicable.

Katherine Management Area

Defence advises that PFAS has moved from the primary source areas on the base via groundwater and surface water.

The Northern Territory Environment Protection Authority advises eating bush food should be avoided in some areas. It is safe to eat some plants and animals from the Katherine region, however, the amount that is eaten should be limited because some species contain higher levels of PFAS. It is safe to eat wild caught fish from the Daly River and outer waterways. However, eating fish, shellfish and crustaceans from Katherine River (between Donkey Camp Weir and Daly River) and Tindal Creek should be limited. There is a very low risk for tourists and visitors who may occasionally eat fish from the affected areas.[61]

In 2017, Defence funded a PFAS water treatment plant for the Northern Territory Power and Water Corporation to filter bore water in the town water supply. To secure a long-term water supply, Defence subsequently agreed to fund the construction and operation of a permanent PFAS treatment plant in Katherine, which will treat up to 10 million litres of water per day. The Northern Territory Chief Health Officer advises that Katherine's public drinking water is safe for consumption.[62] Defence has also provided 100 rainwater tanks to 77 properties that cannot connect to the Northern Territory Power and Water Corporation network, and that used groundwater for drinking.

Since 2019, RAAF Base Tindal has been subject to extensive groundwater remediation. Two groundwater treatment plants continue to operate on the base, and more than 2.5 billion

60 Queensland Health, *Per- and poly- fluoroalkyl substances (PFAS) Factsheet*, 16 July 2019. https://www.qld.gov.au/__data/assets/pdf_file/0020/95312/pfas-fact-sheet.pdf

61 Northern Territory Government, Fish and bush food containing PFAS chemicals, Northern Territory Government website, 2024. https://nt.gov.au/industry/hospitality/accommodation-and-food-businesses/food-safety-and-regulations/food-contamination/fish-and-bush-food-containing-pfas

62 Northern Territory Government, *Frequently asked Questions – PFAS*, March 2017.

litres of water have been treated. Remediation of soil from source areas continues, and to date more than 25,000 tonnes of soil have been disposed of or treated.

Northern Territory government stakeholders have indicated that they would take a similar approach to remediation at RAAF Tindal if it were a site within their jurisdiction.

Remediation

The *National Environmental Protection (Assessment of Site Contamination) Measure 1999* states: "The fundamental goal of remediation should be to render a site acceptable and safe for long-term continuation of its existing use or proposed use where a change of land use is part of the remediation strategy and maximise to the extent practicable its potential future uses."[63]

The PFAS National Environmental Management Plan states "The range of treatment facilities and technology options commercially available to remove and/ or destroy PFAS compounds is limited. More technologies are becoming available or are emerging to remove or immobilise PFAS contamination, but there is limited information on the long-term effectiveness of these methods and their suitability for very large volumes of material."[64]

Defence advises that its remedial approach is to control sources, reduce contaminant movement from the Defence site, and manage risks presented by the contamination. Defence advises this is an established way of managing large-scale contaminated sites when restoration of environmental values is not immediately achievable.

Defence's remediation efforts are generally focused on source areas that are onsite. Defence advises that without addressing the PFAS source, there will be continual movement of PFAS from the base. This means that even if active remediation is possible for off-site areas, without removing the source, these areas could be re-contaminated.

Defence advises that in some circumstances, it may conduct active remediation in off-site areas, where there is an opportunity to achieve a particular outcome. An example is the southern plume near RAAF Base Williamtown, where there is a delineated area of higher PFAS concentrations in groundwater. A remedial options assessment has been conducted for this area and planning is underway to install a pump and treat system to lower groundwater levels to measurably reduce PFAS contaminated groundwater discharging into nearby drains and Fullerton Cove.

Many community members consulted during the Review have expressed dissatisfaction with Defence's efforts to remediate contaminated land beyond base boundaries. Some property owners have expressed a view that remediation of their properties is possible and is only a question of government investment. Others believe that their land is not suitable for use in accordance with the applicable land zoning or existing land uses, and are calling for the land to be acquired or rezoned for industrial or commercial use.

Ongoing remediation research

This Review has not sought to identify or assess the enormous amount of information that is available regarding research and development into technologies and approaches to remediate PFAS in the environment. It is clear that significant resources are being invested by governments, industry and academia, in Australia and globally. The Independent Reviewer is of the view that this investment, combined with the application of artificial intelligence, has significant potential for scalable PFAS remediation options to be developed in coming years. Notwithstanding Defence's active program of research and development, there may be opportunities for Defence to work more closely with organisations such as the University of Queensland and the University of Newcastle, particularly where they have a local presence near key Defence sites.

63 Department of Climate Change, Energy, the Environment and Water, National Environment Protection Council, *National Environment Protection (Assessment of Site Contamination) Measure 1999*, latest version 2013.

64 Department of Climate Change, Energy, the Environment and Water, Heads of EPAs Australia and New Zealand, *PFAS National Environmental Management Plan Version 2.0*, Commonwealth of Australia, 2020.

Soil remediation case study

RAAF Base Richmond, New South Wales[65]
Remediation context: PFAS source areas on Defence sites are often characterised by small volumes of highly impacted soils, and larger volumes of moderately impacted soils.

Remediation approach: activated carbon-based amendments perform well in greatly reducing the leachability of PFAS in soils. Monitoring has shown evidence that stabilisation is an effective remedial solution that is a sustainable alternative to excavation, transport and landfilling or incineration of large quantities of soil. Research conducted by Defence with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has concluded that activated carbon-based amendments have shown no significant degradation in effectiveness overtime.

Remediation in action: RAAF Base Richmond: Defence conducted a remediation options assessment and prepared an action plan. The preferred remediation approach was to use soil stabilisation for moderately impacted soil with lower PFAS concentrations (generally less than 20 mg/ kg of perfluorooctane sulfonate (PFOS) and perfluorohexane sulfonate (PFHXS)) and thermal destruction for soil with higher PFAS concentrations (greater than 20 mg/ kg). 3,900m3 of PFAS-impacted soil was excavated for offsite disposal or treatment with powdered activated carbon. 1,417 tonnes of soil was removed from the base and thermally destroyed at a licenced facility in Victoria. The remaining treated soil was placed back into the excavation and compacted. The performance of the stabilisation works was measured by the reduction in the ability of PFAS to move from the soil into surface waters or groundwater. A series of post remediation tests have indicated a greater than 99 per cent reduction in PFAS concentrations in surface water runoff. Concentrations of PFAS in groundwater monitoring wells within the source areas have also decreased significantly since works were conducted.

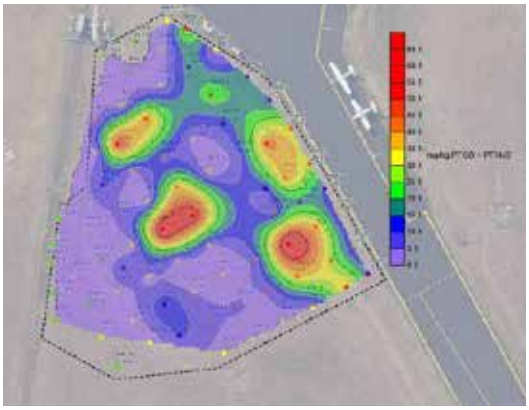


Figure 7: Visualisation of PFAS contamination in surface soils

Feedback: Where do we want to be?

Currency of management areas and precautionary advice

The Independent Reviewer acknowledges the importance of a precautionary approach in reducing potential exposure to PFAS. However, consultation revealed that there were locations within management areas that were not contaminated. Similarly, precautionary advice may apply to properties where sensitive land uses are not conducted. The Independent Reviewer is confident that there is significant potential for precautionary advice to apply with much greater granularity. Precautionary advice that relates to more specific exposure scenarios could assist to better focus risk management and reduce unintended consequences. Similarly, there would be benefit in a national coordinating body considering how the unintended consequences of defined management areas could be mitigated, particularly in relation to property valuations and lending practices.

The Independent Reviewer considers that Defence and state/ territory regulators should work together to ensure that site-specific human health risk assessments remain current. There should be additional focus on ensuring that the size and shape of PFAS management areas and zones, and accompanying precautionary advice, reflects the current understanding of risk. This work should be supported by an explanation of the rationale for

65 Department of Defence, *Short Form Remedial Action Plan, Former Fire Training Ground, RAAF Base Richmond*, report to the Department of Defence, AECOM, 29 October 2020.

the size and shape of management areas and zones, the nature of precautionary advice, and thresholds or triggers for any changes. The Independent Reviewer acknowledges that Defence and the NSW EPA are already discussing potential processes for reviewing whether individual properties can be excised from the Williamtown PFAS Management Area. Additional sampling would help to inform these decisions.

Clear advice regarding prospects for remediation

A clear understanding of the prospects for remediation of PFAS contamination within a PFAS management area (soil, groundwater and surface water) is critical to informing decisions about future land use and zoning. The Independent Reviewer has heard that policy statements and strategic objectives and goals for remediation do not necessarily align with practical options to achieve those outcomes. This contributes to community angst regarding progress towards remediation being either slow or not being achieved. Some members of the community have called for a remediation fund to be established.

The Independent Reviewer acknowledges that achieving remediation goals at the scale needed in the PFAS management areas around the three sites is unprecedented.

The Independent Reviewer has heard that, based on currently available technologies, remediation that would enable precautionary advice to be lifted and permit more sensitive land uses is unlikely in the short-medium term in any of the three PFAS management areas. In part, this is because PFAS contamination at low levels can still result in precautionary advice, and in part because contamination at low levels becomes increasingly difficult and costly to remediate, particularly when it is widespread. The Independent Reviewer accepts that given currently available technologies, complete remediation to remove all PFAS contamination in these three communities is not feasible.

There would be benefit in Defence, in consultation with the national coordinating body and relevant state/ territory authorities, developing clear advice on the prospects for remediation of land and water within the three PFAS management areas. This advice should also address options for management of residual risks. The national coordinating body should consider this advice in order to promote consistency.

Working groups under the national coordinating body should consider how agreed prospects for remediation within the PFAS management areas could inform land zoning, planning and development, including in the context of social, economic and natural capital precincts. This could include how local planning schemes, planning overlays and planning policies and guidance are amended to reflect contamination. The Independent Reviewer considers that integration between all levels of government is needed to assess and resolve second and third order effects of PFAS contamination, including land use and planning decisions.

The Independent Reviewer understands that the scope of the future Commonwealth Environment Protection Australia is not yet finalised. It may have a role in reviewing how Defence assesses and determines approaches for remediation and management of contamination.

It is important that the national coordinating body considers how to embed a national remediation framework across jurisdictions to encourage greater consistency.

Addressing the gap between 'where we are now' and 'where we want to be'

Recommendation 5: That the national coordinating body consider options to mitigate unintended consequences of establishing PFAS management areas and zones, including property valuations and financial lending practices, stigma, and the inclusion of properties that have no or very minimal contamination or risks of exposure to contamination.

Recommendation 6: That Defence and state/ territory authorities take immediate action to confirm that site-specific human health risk assessments, PFAS management areas and zones, and precautionary advice around the three sites remain current. This should occur in consultation with the national coordinating body to promote consistency.

Recommendation 7: That Defence and state/ territory authorities take early action to publish plain English advice on the prospects for remediation of land and water within the three PFAS management areas. This should address the feasibility of relevant remediation technologies, timeframes, sustainability, cost and options for management of residual risks. This should occur in consultation with the national coordinating body to promote consistency.

Recommendation 8: That the national coordinating body review the objectives of national policy for remediation of PFAS contamination to ensure they remain current. This should consider the limitations and practical application of commercially available technologies, and inform long-term management of residual risks.

Actions to implement:

- As a priority, Defence should work with state/ territory authorities to identify the data needed to support a review of human health risk assessments and precautionary advice for the three sites. This should occur in consultation with the national coordinating body to promote consistency.
- Defence and state/ territory authorities should work together to ensure a common understanding of remediation challenges and opportunities around the three sites. This should occur in consultation with the national coordinating body to promote consistency.

Principles to support improved decision-making for land use and planning: Recommendations 9–10

Some property owners continue to live on land that is contaminated and are concerned that this limits how they can use their land. They are concerned that they cannot sell their land at a fair market price. The Independent Reviewer noted differences in land use planning and zoning across jurisdictions, and that planning frameworks typically do not apply retrospectively (including to account for historical PFAS contamination). Some local governments would support more guidance and specific planning controls to help them plan for, and manage, contaminated land.

Assessment: Where are we now?

Planning processes and existing land uses
State/ territory and local government planning requirements differ across jurisdictions, which means there is no consistent management of PFAS contamination in planning, zoning or development. As a general proposition, planning processes are forward-looking and address constraints in the context of new development and approvals. Most planning processes do not look backwards or seek to change existing land uses.

The New South Wales Environment Protection Authority (NSW EPA) regulates sites that have been declared as 'significantly contaminated land'. In most cases, the contamination does not pose a significant risk to human health or the environment. These sites may still need to be remediated, but this can be facilitated through building or redevelopment of the land through planning and development process.

New South Wales
NSW planning authorities regulate contaminated land that is not 'significantly contaminated' through the planning and development process. These lands do not pose an unacceptable risk to human health or the environment under the current, approved use of the land. If contamination makes a site unsuitable for the proposed use, the land must be remediated before it can be developed.

NSW authorities advised "there is no current process for reviewing or determining the suitability of existing land uses where outside of re-zoning or development proposals. Following the grant of a development consent and the commencement of approved developments, there are no triggers within the planning framework to review whether existing land uses are suitable to continue."

There are some examples of where local government is responding to PFAS contamination by adjusting existing planning mechanisms. For instance, Port Stephens Council has managed development in PFAS-impacted areas through existing statutory instruments and NSW EPA guidance, including notation on Section 10.7 (5) planning certificates. Notwithstanding, Port Stephens Council has noted that more specific planning controls to manage land use development beyond the *State Environmental Planning Policy (Resilience and Hazards) 2021* framework would be beneficial in NSW. [66]

66 New South Wales Government, *State Environmental Planning Policy (Resilience and Hazards) 2021,* latest version 2023.

Queensland

The Queensland Department of Environment, Science and Innovation is responsible for providing advice regarding the management of contaminated land in local planning schemes. On particularly large parcels of land with a contaminated site, local governments are encouraged to work with the Department of Environment, Science and Innovation to define the extent of the contamination. During the Review of State Interests, the state interest of 'emissions and hazardous activities' enables consideration of contaminated land.[67] This includes policies that must be appropriately integrated in planning and development outcomes such as protecting sensitive land uses from impacts of contaminated land (including PFAS).

Queensland authorities advise that Queensland's planning framework is not retrospective. It provides for existing land uses to continue in perpetuity, provided they were lawfully established and comply with any development approval requirements. Queensland authorities advised that "A council may review land uses as part of their strategic planning, for example in preparing local housing strategies, to identify better uses of land having regard to the future growth of the area. Likewise, a landowner may request a re-zoning to enable a higher and better use of their land. However, in both of these scenarios the review of the land use would not be focused on whether the existing land use is suitable".

Toowoomba Regional Council declined to provide comment to the Review, noting ongoing legal action against the Commonwealth in relation to PFAS contamination around Swartz Barracks.

Northern Territory

The Northern Territory Environment Protection Authority manages the assessment of contamination for sites that threaten to pose serious or material environmental harm, or harm to human health, through an integrated framework shared between it and the Northern Territory Department of Infrastructure, Planning and Logistics.

This integrated approach is led by the Department of Infrastructure, Planning and Logistics through the land use planning and approvals process, with input requested from the Environment Protection Authority. The Department of Infrastructure, Planning and Logistics may request an assessment of site contamination, or site audit statement. This would occur as a condition of a Development Permit, for example when there is a change of land use to a more sensitive use or sensitive use subdivision, or there is evidence of current or historical potentially contaminating activities.

In the Northern Territory, planning and zoning decisions are made by the Territory Government with minimal local government involvement. This is quite different to New South Wales and Queensland, where the majority of routine zoning and planning decisions are made at the local government level. During consultation, Katherine Town Council expressed some frustration with the Northern Territory planning process. Decisions were made for Katherine from Darwin, although Katherine Town Council is expected to undertake the public consultation process on zoning and planning issues. Any process to register contamination on a property title also sits with the Northern Territory Government, rather than Katherine Town Council.

Recording details of contaminated land

State/ territory governments have different processes for registering land contamination, and different criteria for adding or removing a property from a register. Purchasers of property are often not provided with clear advice on either the contamination status of land or any precautionary advice that may apply to land.

In New South Wales, the Managing Land Contamination – Planning Guidelines provide advice to planning authorities on issues including identification of contaminated sites, and consideration of contamination in rezoning and development applications.[68] Planning certificates can provide useful information to prospective home buyers. They should include information on land or water contamination – whether the contamination is current, remediated or has never occurred on the site – allowing purchasers to make informed decisions.

In 2020, the New South Wales Environment Protection Authority conducted a Review of contaminated land information on planning certificates in NSW to better understand how local councils presented contaminated land information on Section 10.7 planning certificates.[69] The review found that councils varied greatly in how they provided contaminated land information.

67 Queensland Government, *Review of State Interests Consultation Report*, Department of Infrastructure, Local Government and Planning, 2017.

68 New South Wales Government, *Managing Land Contamination, Planning Guidelines, SEPP 55-Remediation of Land*, Department of Urban Affairs and Planning, Environment Protection Authority, 1998.

69 State of New South Wales, *Review of contaminated land information on planning certificates in NSW*, NSW Environment Protection Authority, 2022.

The review made recommendations to address the identified issues and provided guidance for councils about the presentation of contaminated land information. In feedback to the New South Wales Environment Protection Authority's review, some councils stated that they had received legal advice that providing too much information on planning certificates is a privacy and commercial-in-confidence risk, and therefore information is often kept as succinct as possible. They sought stronger and clearer guidelines on what councils are legally required to provide on planning certificates.

The Queensland Department of Environment, Science and Innovation is responsible for administering the state's Environmental Management Register and Contaminated Land Register.[70] The Environmental Management Register is a public register that contains information about land which is, or could potentially be, contaminated because it is being used for an activity that may cause contamination. The Environmental Management Register is a land-use planning tool used to ensure that potential risks are appropriately considered for the activities on the land, use of the land, and for any proposed development. The Environmental Management Register also enables potential buyers of the land to be fully informed about the status of a site. Contaminated land is moved from the Environmental Management Register to the Contaminated Land Register where it is necessary to take action to remediate the land to prevent serious environmental harm and protect human health or other aspects of the environment. Local government is formally notified when properties in the local government area are listed on the Contaminated Land Register. If the Department of Environment, Science and Innovation places a parcel of land on the Environmental Management Register/ Contaminated Land Register and therefore limits its use, it would result in development applications on that land being assessed by the State. It may also have a significant impact on a landholder's ability to source finance for that land and may impact valuations.

In the Northern Territory, where contamination is regulated by the Environment Protection Authority, all information received for a parcel of land (including any regulatory notices issued and audit reports) will be provided on the Public Register. The Public Register is a legislated requirement and provides transparency on decision-making and regulatory enforcement activities under the *Waste Management and Pollution Control Act 1998*.

Feedback: Where do we want to be?

The Independent Reviewer acknowledges that state/ territory and local governments are not proposing to institute any additional planning measures to address potential risk arising from PFAS contamination, or to support existing land uses. The Independent Reviewer accepts that state/ territory and local governments may be reluctant to establish additional planning controls to manage risks as the need for compensation would inevitably arise.

However, there is a strong case for greater collaboration across all levels of government to develop principles and guidance that support strategic consideration of land uses in areas of higher PFAS contamination. These principles need to be practical and able to be implemented through local and state/ territory planning schemes and processes. This is particularly important for local governments, which generally have less visibility of policy considerations and changes regarding PFAS contamination, but are often required to manage and determine land use, development and planning in areas of contamination. It is also particularly important in areas where contamination occurs across multiple jurisdictions.

National guidance for planning and development, and managing historical contamination

State/ territory frameworks for managing contamination are not designed with a view to regulating the Commonwealth, and core elements of the frameworks do not operate as intended when the Commonwealth is the polluter. For example, the Queensland Department of Environment, Science and Innovation advises that the key features of enforcement actions taken under the *Environment Protection Act 1994* are to mitigate pollution or contamination incidents where landowners and/ or operators are issued with written statutory instruments that require specific actions to be undertaken within specified timeframes.[71] Non-compliance may lead to penalty

70 Queensland Government, *About the land registers*, Queensland Government website, 2023. https://www.qld.gov.au/environment/management/environmental/contaminated-land/registers/about-registers

71 Queensland Government, *Environmental Protection Act 1994,* latest version 2024.

infringement notices, prosecution or suspension or cancellation of environmental permits, licences or authorities. This approach is complicated when the Commonwealth is the polluter. The Independent Reviewer considers that this disconnect means that around the three sites, Defence and the state/ territory regulators have not always managed to reach consensus on necessary actions and strategic goals.

The national coordinating body could work with jurisdictions to agree new principles to be included in the PFAS Intergovernmental Agreement. The Independent Reviewer considers that new approaches could ensure that state/ territory and local government land planning better accounts for known PFAS contamination. This is particularly important where PFAS contamination is widespread at relatively low levels, but has still resulted in precautionary advice being issued. Planning scheme overlays applied by jurisdictions for bushfire and flood zones may provide an example for how PFAS contamination could be addressed.

There may be value in the national coordinating body providing further guidance on opportunities to reassess existing land uses, outside of the typical development application process and particularly in the context of historical contamination. This could be supported by more specific development controls or guidance to manage exposure for implementation by jurisdictions.

The Independent Reviewer understands that there are a number of areas where all governments are working together to address issues of land use and zoning. For example, the National Cabinet has prioritised the development of a 'National standard for considering disaster and climate risk in land use planning'.[72] The Planning Ministers' Meeting Communique of August 2023 stated that "Planning Ministers agreed to the NSW Government leading the development of a framework and guidance on nationally agreed principles for natural disaster and climate risk considerations in land use planning decisions".[73] The Independent Reviewer considers that principles that apply to amendments to land planning frameworks to better account for increased flooding and bushfire events may help to inform planning for potential constraints presented by PFAS contamination. National guidance and principles that strategically consider land uses in areas of higher PFAS contamination are also important for precinct development.

Recording details of contamination on property titles

The Commonwealth Government, and state/ territory governments maintain registers detailing contamination status of land in their jurisdictions. While these registers are broadly for similar purposes, the way they are used differs significantly from one jurisdiction to another.

There is significant potential to improve how information is shared and used across levels of government, and particularly with local governments. Community members told the Independent Reviewer that some purchasers of property in a PFAS management area were unaware of the contamination status of a property, or the applicable precautionary advice. While there are multiple ways that purchasers could be provided advice, the national coordinating body may wish to consider the merits of providing further national guidance regarding recording contamination issues on property titles or planning certificates, which could be implemented through state/ territory and local government frameworks. Even if formal guidance is not considered necessary, greater consistency would be welcome.

Improving transparency about historical contamination should increase certainty for affected property owners about what they can do on their properties. The potential for unintended consequences of retrospectively including contamination status on property titles would need to be considered, including impacts on property values and availability of financing.

The Independent Reviewer acknowledges the concerns of state/ territory and local governments that any decision to change existing land zoning or uses, or to include notices on property titles as a result of PFAS contamination, may result in a need to pay compensation. The national coordinating body would be well placed to consider and develop advice on this issue.

72 National Cabinet, *National Cabinet's priorities*, Federation website. https://federation.gov.au/national-cabinet

73 Minister for Infrastructure, Transport, Regional Development and Local Government, *Planning Ministers' Meeting 2023 Communique*, The Hon Catherine King MP, Minister for Infrastructure, Transport, Regional Development and Local Government website, 4 August 2023.

Addressing the gap between 'where we are now' and 'where we want to be'

Recommendation 9: That the national coordinating body consider the need for further national guidance regarding planning and development in the context of historical contamination that may impact existing land uses. Any new guidance could be implemented through state/ territory and local government frameworks.

Recommendation 10: That the national coordinating body consider the merits of providing further national guidance regarding recording contamination on property titles, including to improve consistency across jurisdictions. Any new guidance could be implemented through state/ territory and local government frameworks.

Actions to implement:

- The national coordinating body should establish a working group to review relevant planning processes and guidance, including progress under the National Cabinet's priority of developing a 'National standard for considering disaster and climate risk in land use planning'.

Managing risk associated with land uses in PFAS management areas: Recommendations 11-15

Some property owners are concerned that precautionary advice does not protect them from contamination. Others indicated that the precautionary advice is not feasible to implement. People growing food are concerned about advice that they should not eat their own produce, but can sell it into the market. Other food producers are concerned about evolving international approaches to management of PFAS in foods. They want advice and support from governments to address these issues.

Assessment: Where are we now?

Land uses that require additional consideration

Current human health advice and PFAS management controls indicate that most permitted land uses in PFAS management areas can continue. This also acknowledges that a significant number of legal claims have been resolved. However, the Independent Reviewer has identified two cohorts of property owners where impacts of PFAS contamination require additional consideration, and potentially support, from governments. These are:

- primary producers on properties with livestock that are assessed as having PFAS levels of concern relevant to maximum limits imposed by the European Union
- property owners for whom it may not be possible or reasonable to implement precautionary advice to mitigate identified human health risks.

Health Investigation Levels

The dual purpose of contaminated site assessments is to determine the human health and ecological risks associated with existing site contamination and to inform any remediation or management plan to make the site fit for the proposed land use. Health Investigation Levels are scientifically-based, generic assessment criteria designed to be used in the screening stage of an assessment of potential risks to human health from chronic exposure to contaminants. They are intentionally conservative and are based on a reasonable worst-case scenario for specific land use settings.[74] They are derived for four generic land use categories as follows:

- Health Investigation Level A - Standard residential with garden/ accessible soil (homegrown produce <10 per cent fruit and vegetable intake, (no poultry), includes children's day care centres, preschools and primary schools
- Health Investigation Level B - Residential with minimal opportunities for soil access, includes dwellings with fully and permanently paved yard space such as high-rise buildings and flats

74 National Environment Protection Council, *National Environment Protection (Assessment of Site Contamination) Measure 1999, Schedule B7, Guideline on Health-Based Investigation Levels*, April 2011.

- Health Investigation Level C - Includes developed open space such as parks, playgrounds, playing fields (for example ovals), secondary schools and footpaths. Does not include undeveloped public open space, which should be subject to a site-specific assessment where appropriate
- Health Investigation Level D - Commercial/ industrial includes premises such as shops, offices, factories and industrial sites.

PFAS in the food supply

Food Standards Australia New Zealand monitors the safety of the food supply through the Australian Total Diet Study, which looks at consumers' exposure to a range of chemicals found in food. The 27th Australian Total Diet Study, published in December 2021, sought to obtain data on PFAS levels in the general food supply and to estimate dietary exposures for the general population as this information was previously not available.[75] The study focussed on a range of PFAS due to concerns in Australia related to contamination of sites where there has been historical use of PFAS-containing firefighting foam. The study found that:

- levels of PFAS in Australian foods were consistently lower than those found in overseas studies conducted in Europe, the United States, the United Kingdom and China
- levels of PFAS were well below Australian guidance values including Food Standards Australia New Zealand trigger points for site investigation and National Health and Medical Research Council drinking water guidelines
- the overall dietary exposure to perfluorooctane sulfonate (PFOS) for the general Australian population is lower than the Tolerable Daily Intake, indicating no public health and safety concerns.

As a result, there was no justification for establishing food regulatory measures such as maximum levels for PFAS in the Australia New Zealand Food Standards Code.

The Independent Reviewer was told that while PFAS levels in the general food supply may be low, areas around the three sites were different, and advice and support for impacted communities about food production and consumption needed to be improved. For example, community members wanted greater explanation of, and justification for, advice that food produced in a management area is not suitable for home consumption but could be sold into the general market. Some property owners consulted said that regardless of the regulatory position, they were either unwilling or unable to sell their livestock to market for ethical reasons, and/ or for practical reasons relating to the stigma associated with buyers accepting produce from a contaminated area. Consultation with some community stakeholders indicated this had significantly impacted their financial circumstances. Currently there are no restrictions on the domestic trade of agricultural products containing PFAS.

In December 2022, the European Union established maximum levels for various PFAS in a range of produce.[76] To date, the European Union is the only market that has established maximum levels for PFAS. The Commonwealth Department of Agriculture, Fisheries and Forestry advises that it is working with SAFEMEAT[77] to investigate potential options for managing livestock turned off properties assessed to have a risk of PFAS contamination.

Consultation indicated that some primary producers are concerned that they will not be able to implement the mitigations that may be necessary to meet international requirements for PFAS in food.

Consultation also identified that some primary producers and irrigators are unsure of whether they can legally extract and use groundwater, and are concerned about whether they can be held responsible for spreading contamination through irrigation under current policy frameworks. This issue is managed differently across jurisdictions.

The Independent Reviewer notes that the State of Maine in the United States of America, as part of a broader response to PFAS contamination issues, is actively testing for PFAS and assisting farmers, primarily in the context of PFAS contamination resulting from the application of biosolids. No federal standards have been created for food in the United States, but Maine has established a perfluorooctane sulfonate (PFOS) Action Level for beef and milk. The Maine Department of Agriculture has published guidance documents including practical risk mitigations for producers,

75 Food Standards Australia New Zealand (FSANZ), *27th Australian Total Diet Study, Per- and poly-fluoroalkyl substances*, FSANZ, 2021.
76 European Union, *Commission Regulation 2023/915 of 25 April 2023 on maximum levels for certain contaminants in food and repealing Regulation (EC) No 1881/2006*, EUR-Lex website, 2023.
77 SAFEMEAT is a partnership between the red meat and livestock industry and state and federal governments of Australia. This partnership ensures that Australian red meat and livestock products achieve the highest standards of safety and hygiene from the farm to the consumer.

relevant at an individual property level.[78] Maine has also established a fund to address impacts of PFAS contamination for eligible farmers, including to reimburse costs associated with PFAS testing, address costs associated with groundwater filtration systems, assist with infrastructure and operational costs, assist with income support, and provide compensation for livestock depopulation.[79]

Property owners who cannot reasonably implement precautionary advice

For some property owners in management areas, there may be circumstances where implementing precautionary advice is not feasible or practicable. Typically, this would be in areas where contamination is the most significant, or where significant exposure pathways cannot be broken. One example may be low-lying areas of land in the Williamtown PFAS Primary Management Zone, where the high water table means that significantly contaminated groundwater often remains above the ground for extended periods.

It is expected that only a limited number of properties would not be able to reasonably or feasibly mitigate human health risks. While an understandable community concern, this cohort would not encompass circumstances such as residential property owners who are unable to grow their own fruit or vegetables (which the Independent Reviewer assesses can be reasonably and feasibly be mitigated), or where property values may have been impacted (not a human health risk).

Addressing residual concerns and claims from property owners

The Independent Reviewer notes that through a range of legal proceedings, including class actions and non-litigated claims, a significant number of property owners in the management areas around the three sites have received varying amounts of compensation from the Commonwealth relating to PFAS contamination. This typically includes for loss in value of property, and for inconvenience, distress and vexation. However, a number of property owners expressed dissatisfaction with the legal claims process. These concerns included the process being overly bureaucratic, the timeliness in resolving claims, and the quantum of compensation paid. At Williamtown, the Independent Reviewer heard that the class action settlement was "a band-aid on a gaping wound".

Feedback: Where do we want to be?

Health Investigation Levels for food production

The Independent Reviewer has identified that the framework for management of PFAS contamination needs to provide clearer guidance for land uses that involve food production. Existing Health Investigation Levels focus on ingestion of soils and water. While acceptable water quality for the protection of environmental values is defined, including agricultural use for stock watering and irrigation, fresh and marine ecosystems, and recreational use, this is related to the health of livestock. It is not related to uptake of PFAS by livestock, and the potential for subsequent ingestion of PFAS by humans. The existing Health Investigation Levels are expected to be reviewed as part of the scheduled review of the *National Environment Protection (Assessment of Site Contamination) Measure 1999*.[80] The Independent Reviewer understands that new guideline values for livestock watering are being considered. New guideline values that could inform an assessment of risk related to food production may also be beneficial.

Supporting primary producers

Mitigating risks of PFAS contamination related to primary production in these areas is more complicated than for most other land uses. The Independent Reviewer acknowledges the work underway through the Department of Agriculture, Fisheries and Forestry, and SAFEMEAT, to investigate potential options for identifying and managing livestock production on properties assessed as having PFAS levels of concern in regard to maximum limits imposed by the European Union. It is noted that this work is focussed on the integrity of supply to export markets.

78 Maine Department of Agriculture, Conservation & Forestry, *PFAS Response*, Maine Department of Agriculture, Conservation & Forestry website. https://www.maine.gov/dacf/ag/pfas/pfas-response.shtml

79 Maine Department of Agriculture, Conservation & Forestry, *PFAS Assistance*, Maine Department of Agriculture, Conservation & Forestry website. https://www.maine.gov/dacf/ag/pfas/pfas-assistance.shtml

80 Department of Climate Change, Energy, the Environment and Water, National Environment Protection Council, *National Environment Protection (Assessment of Site Contamination) Measure 1999*, latest version 2013.

The Independent Reviewer assesses that while the outcome of this work is not yet known, measures to meet European Union and other potential international standards for PFAS in foods could include:

- separating livestock from contaminated water
- rotating stock
- using point of use filters on groundwater bores, to enable groundwater to continue to be extracted and applied to land or livestock (issues including maintenance and waste would need to be considered)
- tilling stabilisation/ immobilisation agents into productive farmland to prevent uptake of PFAS.

Some of these measures may benefit from additional research or trials, and would require close collaboration between relevant Commonwealth, state/ territory and local governments. All potential options would be site-specific and would depend on the circumstances of an individual primary producer.

The Independent Reviewer considers an independent assessor or assessors should be appointed to identify primary producers in the three PFAS management areas, and to assess the feasibility of implementing the risk mitigation measures. Assessments could be undertaken by a contaminated site auditor accredited by the relevant state/ territory, accompanied by an industry expert. The outputs of this assessment could inform the Australian Government and inform an understanding of residual property risk.

If risk mitigation measures are assessed as not being feasible to implement and residual risk exists, the Australian Government should consider working collaboratively with state/ territory and local governments to support producers. This could include provision of information, financial assistance to implement the measures, bespoke remediation efforts, or potentially rezoning land or voluntary acquisition of property, including by state/ territory or local governments.

Managing human health risks

Australia's health advice states that PFAS has not been shown to be a cause of disease in humans, but acknowledges that the science and understanding of these issues will continue to evolve. As a precaution, it is therefore recommended that exposure to PFAS be minimised wherever possible. The Independent Reviewer has heard from some property owners that implementing precautionary advice to reduce exposure to human health risks can be difficult to achieve.

The Primary Management Zone adjacent to RAAF Base Williamtown is arguably subject to the most stringent precautionary advice of any site in Australia. Contamination levels can be significant, and the hydrogeology of the area makes PFAS remediation and management extremely complex. The Independent Reviewer considers that conducting a limited number of property-specific assessments would help inform governments of the need for any additional options to practically manage human health risks. These independent assessments would also enhance public understanding of actual exposure risks and mitigations, and demonstrate real-world application of precautionary advice.

The Independent Reviewer considers that a contaminated site auditor accredited by the New South Wales Environment Protection Authority should be appointed to assess PFAS exposure risk for people living in the Williamtown Primary Management Zone. If human health risks for residents of a property cannot be reasonably or feasibly mitigated, the Australian Government should consider working collaboratively with state/ territory and local governments to provide additional support to the property owner. This could include financial assistance to implement mitigations, bespoke remediation efforts, or potentially rezoning land or voluntary acquisition of properties, including by state/ territory or local governments.

Potential costs

Potential costs associated with providing support to these two cohorts of land users are likely to vary, based on the level of support provided. While costings have not been undertaken as part of this Review, the following scenario could be considered in the context of any voluntary acquisition of properties:

There are approximately 65 properties in the Williamtown Primary Management Zone, which for the purpose of this scenario are estimated to be valued at $1.5 million per property.

If an independent assessment of properties in the Williamtown Primary Management Zone indicated that human health risks could not be mitigated at a number of those properties, and a decision was taken to acquire them on a voluntary basis, this could cost $97.5 million. These figures represent the potential property costs only, and additional costs would be incurred in establishing and administering a property acquisition program at scale.

Independent mediation process

The Independent Reviewer has considered ongoing land use within the context that a significant number of legal claims have been settled. While the Independent Reviewer welcomes this progress, he considers that there would be merit in establishing an independent mediator/ mediation panel to hear community concerns and to seek to progress them. Not all property owners have participated in legal action, and a range of community concerns are likely able to be considered and resolved outside of a formal legal framework, such as enquiries about process and communication. Some claims would still require resolution through established legal processes. The nature of issues within scope for mediation would need to be clearly defined.

Where property owners have settled legal claims with the Commonwealth relating to PFAS contamination (including through class actions), the terms of those settlements may be relevant to whether property owners have further recourse to a mediation process. Property owners would generally not be able to raise issues in this mediation process that have been settled through a legal claim. The Independent Reviewer notes that in ordering the settlement of the class actions pertaining to communities around RAAF Base Williamtown, the Army Aviation Centre Oakey (now Swartz Barracks) and RAAF Base Tindal, the Hon Justice Michael Lee stated that "...there is no ability for either the applicants or the group members to maintain a claim against the Commonwealth with respect to the damages the subject of these class actions which, as noted above, do not include any claim for personal injury."[81]

Addressing the gap between 'where we are now' and 'where we want to be'

Recommendation 11: That the national coordinating body ensure additional policy guidance is developed to address risks associated with food production in the context of PFAS contamination, including developing new Health Investigation Levels that will inform risk assessments for the suitability of relevant land uses.

Recommendation 12: That the national coordinating body ensures early action is taken to develop additional guidance for primary producers to meet national and international standards for PFAS in food.

Recommendation 13: In the context of Recommendations 7 and 12, that the national coordinating body take immediate action to appoint an independent assessor to work with Commonwealth and state/ territory authorities to identify primary producers in management areas around the three sites. If measures to meet European Union and other potential international standards for PFAS in foods are assessed as not being feasible to implement and residual risk exists, the Commonwealth should consider working collaboratively with state/ territory and local governments to provide additional support to producers.

Recommendation 14: In the context of Recommendations 2, 6 and 7, that Defence work with the national coordinating body and the New South Wales Government to take immediate action to appoint an independent assessor to assess PFAS exposure risks for properties in the RAAF Base Williamtown Primary Management Zone. If human health exposure risks for residents of a property cannot reasonably be mitigated, for example through implementing precautionary advice or remediation activities, the Australian Government should consider working collaboratively with state/ territory and local governments to provide additional support to the property owner. This could include rezoning or the voluntary acquisition of properties, including by state/ territory or local governments. Outcomes of these assessments would inform options for the Australian Government to manage risks in other zones in the Williamtown Management Area, and in the PFAS management areas around Swartz Barracks and RAAF Base Tindal.

Recommendation 15: That Defence work with the national coordinating body to take immediate action to establish an effective and impartial mediator/ mediation panel, empowered to hear from property owners in the PFAS management areas around the three sites and address residual concerns or claims as a result of PFAS contamination. This mediation process would complement the existing legal claims process. Mediation would occur within an established framework to guide the nature of issues to be

81 Federal Court of Australia, *Smith v Commonwealth (No 2) [2020] FCA 837*, date of judgment 5 June 2020.

considered by the independent mediator/ mediation panel, and how resolution may be achieved. Some property owners have settled legal claims relating to PFAS contamination with the Commonwealth, including through class action processes. The terms of those settlements may be relevant to whether individual property owners have further recourse to a mediation process.

Actions to implement:

- Defence and the national coordinating body should commence development of a framework which identifies issues to be considered by the independent mediator or mediation panel and clarifies options for resolution of those issues.

Social, economic and natural capital precincts: Recommendations 16–19

Some property owners want choices and options for what they can do with their land where precautionary advice imposes limits. Voluntary rezoning and repurposing of land would provide such choices and options. Stakeholders support a range of suitable options for voluntary repurposing. These include use of land by industry, or for broader environmental outcomes such as biodiversity and nature repair.

Assessment: Where are we now?

The Independent Reviewer has found that with precautionary advice being implemented, most land uses in PFAS management areas surrounding each of the three bases can continue. However, the Independent Reviewer has heard that PFAS contamination has led to some distortion of property markets, investment and development. This Review has also identified a number of limitations in existing planning processes, lack of confidence in health advice, and a need for clarity around prospects for remediation of contaminated land and water.

These limitations provide a basis for some government intervention, particularly to provide planning guidance and streamlined approvals processes to facilitate investment and development opportunities. Such government intervention would encourage greater industry and community engagement regarding proposed development, and the management and remediation of PFAS.

RAAF Base Williamtown, Swartz Barracks and RAAF Base Tindal are significant and enduring military bases that deliver key capabilities for Defence. Each base will continue to contribute to the social and economic fabric of the respective local area and wider region. The Independent Reviewer understands that, over the coming years, significant investment is planned for RAAF Base Tindal and RAAF Base Williamtown in particular. The Independent Reviewer has heard from local and state/ territory governments that they seek greater visibility of Defence strategic planning, future investment, and capability needs and requirements. Increased transparency would enable state/ territory and local governments to prioritise and schedule their own planning and complementary investments, including for supporting infrastructure such as roads and accommodation.

The Independent Reviewer was advised that at times, Defence will seek to move ancillary support and contractor operations from on base to areas outside of a base, particularly where space on base is limited. This creates increased opportunities for a range of industries that are compatible with Defence activities to be around Defence bases. The long-term nature of Defence capability and planning, and the scale of Defence investment, provides unique opportunities to work with state/ territory and local governments to plan future infrastructure and development needs. Broader Defence capability needs and growth may also support future strategic and targeted acquisitions of properties in areas proximate to bases to support Defence capability. There may be opportunities to align these requirements with assessments of land use in the context of PFAS contamination.

This may also create opportunities and drivers for voluntary repurposing of land in a way that may not feature in state/ territory and local government planning.

The Independent Reviewer noted Defence's interests in relation to land use or zoning around bases, including to minimise development that is incompatible with the operation of a base, and to minimise urban encroachment that may impact Defence operations.

Future land uses

Consultation revealed a range of views on what should happen with PFAS-impacted properties. In all cases, property owners want to be able to make their own decisions about their futures, and want agency in how they live and work on their land.

Many property owners want to stay on their land, but on the basis that they can regain full and unencumbered use of their property for its permitted uses. Other property owners want to be able to sell their properties at a price that assumes PFAS contamination is not present. Some of these property owners do not want to wait for further strategic planning that may deliver rezoning or other development over coming years. This is particularly the case at Williamtown where many property owners in the Primary Management Zone expressed significant frustration about the cancellation of the Williamtown Special Activation Precinct that had been proposed by the former New South Wales Government, and which would have involved the acquisition of a number of properties in the area.[82]

Williamtown Special Activation Precinct

In New South Wales, Special Activation Precincts (SAPs) support planning and delivery of industrial and commercial infrastructure projects to attract and grow businesses, support employment and stimulate regional economies. The now-cancelled Williamtown Special Activation Precinct was a 395 hectare site adjoining the Newcastle Airport and RAAF Base Williamtown. The decision not to proceed with the Williamtown Special Activation Precinct was made on the basis that the funding needed to address the complex hydrology, flooding and drainage issues at Williamtown made the development cost prohibitive.[83]

The New South Wales Government advises that the decision not to proceed with the Williamtown Special Activation Precinct means that "land will not be rezoned, therefore landowners' current land uses remain as is and they may lodge development applications in accordance with current planning pathways". However, historical land constraints including flooding, drainage and water quality, which have acted as barriers to development, remain.

The Independent Reviewer heard that planning powers for the Williamtown area were temporarily held by the New South Wales Government during planning for the Williamtown Special Activation Precinct. These planning powers have now reverted to the Port Stephens Council.

Property owners were broadly supportive of repurposing and rezoning land, on a voluntary basis, in the management areas. There was a general view that rezoning could increase property values through optimising the available uses of land. Property owners, state/ territory and local governments and industry proposed a number of potential land uses. There was strong support for development to contribute to defence capabilities in areas proximate to the bases. There was also support for broader rezoning to enable commercial and industrial development, aerospace technologies, and environmental and social outcomes.

Williamtown drainage network

Stakeholder consultation indicated that some approved changes to drainage networks, including diversions of drains, had adversely impacted other properties. The distributed accountability for drainage infrastructure across all levels of government and private property owners has resulted in a lack of integrated management of the drainage network, and is an ongoing barrier to maintenance and potential improvement of the drainage network.

Traditional Owners across the three impacted communities emphasised the importance of their connection to Country. They emphasised a desire for any future development around the bases to include Indigenous cultural and business opportunities that are compatible with the contamination status of the land, and that could benefit their communities.

During consultation, the Independent Reviewer was told that compensation property owners had received through settlement of class actions or other legal claims was insufficient to enable

82 The Williamtown Special Activation Precinct was first announced by the former New South Wales Government in May 2020. The Precinct took a coordinated approach to addressing historical land constraints including flooding, drainage and water quality, which have acted as a barrier to development in the past. Land within the Precinct was to be rezoned to allow for new commercial and industrial land uses, delivered over 40 years. Following the New South Wales Government's 2023 Strategic Infrastructure Review, the New South Wales Government decided not to proceed with the Precinct.

83 New South Wales Government Planning, Williamtown Special Activation Precinct, NSW Government Planning website, 2024. https://www.planning.nsw.gov.au/plans-for-your-area/special-activation-precincts/williamtown-special-activation-precinct

property owners to sell their properties and purchase an equivalent property in an area that was not affected by PFAS contamination (which they termed 'like for like'). The Independent Reviewer notes that in ordering the settlement of the class actions pertaining to communities around RAAF Base Williamtown, the Army Aviation Centre Oakey (now Swartz Barracks) and RAAF Base Tindal, the Hon Justice Michael Lee stated : "In my view, the settlements are fair and reasonable and in the interests of group members in all three proceedings..."[84]

In any case, property owners believed that in the open market, buyer interest was limited and prices offered for properties was lower due to properties being located in a PFAS management area and being subject to associated precautionary advice.

The Independent Reviewer acknowledges the concerns of community members regarding the number and value of property sales in each of the three PFAS management areas. While there are many issues that could be relevant, a number of qualitative factors, which may impact on value of properties in PFAS management areas, include:

- stigma, potentially leading to a loss in property value due to perception of a risk, whether that risk is present or not
- conservative valuations, especially in the context of lending. This will be amplified where stigma exists, and will impact on a property owner or property buyer's ability to obtain financing
- limited sales data, including because property owners may avoid trying to sell a property due to concerns about potentially realising a loss.

Land planning for leased federal airports

The Department of Infrastructure, Transport, Regional Development, Communications and the Arts advised the Independent Reviewer that leased federal airports were required to develop a Master Plan, with a 20-year planning horizon, in accordance with the requirements set out in the *Airports Act 1996*.[85] Depending on the designation of the airport, Master Plans are to be submitted to the relevant Minister for consideration either every five or eight years.

The Master Plans are required to include an Airport Environment Strategy that, among a range of considerations, provides details of the airport's PFAS management plan. The PFAS management plan would need to consider levels of contamination, which may vary across precincts on the airport site.

An updated Australian Noise Exposure Forecast (ANEF) is required to be included in each new Master Plan to indicate the noise impacts on areas close to the airport. The ANEF is primarily a land use planning tool to inform state and local government decisions on developments around airports. Steps may be taken to minimise impacts through airspace design, noise abatement procedures and land use planning.

In addition, the National Airports Safeguarding Framework has been established by Commonwealth and state/ territory government agencies, including Defence, as a national land use planning framework that aims to:

- improve community amenity by minimising developments that are sensitive to aircraft noise near airports
- improve safety outcomes in land use planning decisions through guidelines adopted by jurisdictions on various safety-related issues.

While in a different context, this framework could be a useful example of how land planning could consider PFAS contamination.

84 Federal Court of Australia, *Smith v Commonwealth (No 2) [2020] FCA 837*, date of judgment 5 June 2020.

85 Department of Infrastructure, Transport, Regional Development, Communications and the Arts, *Airports Act 1996*, latest version 2023.

Feedback: Where do we want to be?

Management of local drainage networks
The high water table at Williamtown is a significant constraint on local planning and development. It contributes to localised flooding, and is an important factor in the localised movement of PFAS. Improved drainage may reduce the time that surface water remains on the ground, and may therefore make the land more useable.

Property owners have long called for active and coordinated management of local drainage networks. Many stakeholders noted that creating a formal coordination structure to manage the drainage network would be an essential step in improving the performance of the network. This structure could also support development of a drainage catchment management plan and easements. Stakeholders requested that options to increase discharge flows from the drainage network into Fullerton Cove be explored, including environmental impacts.

Some of these measures can be addressed in the near term, and are likely to improve the efficiency of the existing drainage network. This could reduce the duration of inundation events, and may provide for greater use of land by property owners more immediately.

Williamtown – a strategic business case for a social, economic and natural capital precinct
In exploring PFAS contamination and land uses in the Williamtown PFAS Management Area, the Independent Reviewer has identified a significant opportunity to build on the work undertaken by the New South Wales Government in planning for the Williamtown Special Activation Precinct.

The Independent Reviewer acknowledges the work undertaken by Aurecon Australasia Pty Ltd to progress development of a strategic business case that could drive the creation of a social, economic and natural capital precinct in Williamtown (Attachment D).

A social, economic and natural capital precinct would focus on exploring alternate land use options for PFAS-impacted areas, and:

- determine opportunities for development while considering repurposing and/ or coexistence with PFAS-impacted lands. This would not be limited to traditional 'highest' value land uses, but would primarily explore best complementary/ compatible use of PFAS-impacted lands. This is a key differentiator to the Williamtown Special Activation Precinct
- identify the economic and social needs of the region and determine catalytic industries that could act as a pillar for growth and change, encourage social equity and add value to encumbered properties
- identify strategic opportunities to harness the best use of the land over multiple time horizons, acknowledging constraints such as PFAS, supply/ demand, investment opportunities and unique value propositions
    - it is acknowledged that PFAS contamination in some areas may be prohibitive to development in the short term, but there may be opportunities to unlock potential over time, including following remediation activities and as environmental constraints evolve.
- balance economic growth and environmental outcomes by harnessing and enhancing the natural capital of the area
- encourage a sustainable and coordinated development approach, prioritising strategies that promote nature, biodiversity and ecological resilience.

The extensive technical investigations that informed the Williamtown Special Activation Precinct provide an important body of evidence for understanding the local complexities and opportunities, and inform the identification of alternative land uses for PFAS-impacted land in a social, economic and natural capital precinct.

The traditional approach to master planned precincts is to identify sites that will meet particular criteria or development objectives. Often master planned developments consider a binary land use change, usually to a 'highest and best value' option and balanced by staging land releases so as not to saturate a market. This serves to control development and focus investment spending, which are positive outcomes. However, this approach to development may leave some areas behind until supply and demand justifies rezoning.

The Independent Reviewer considers that while not following the traditional approach, master planned social, economic and natural capital precincts remain the best way to optimise the future use and value of PFAS-affected land to benefit these three communities.

Principles for social, economic and natural capital precincts

Establishing a social, economic and natural capital precinct presents a unique opportunity to transform PFAS-impacted sites, adding salient and intrinsic value to communities whilst driving regional economic growth and enhancing social and natural capital outcomes. A social, economic and natural capital precinct aims to drive value creation across all levels of site potential, including on (often overlooked) constrained areas. Important to this process is that master planning of communities is founded on clear, value-based principles that seek to build on land development best practice.

The Independent Reviewer proposes that through social, economic and natural capital precincts, governments can explore options to support renewal and growth in areas that are constrained by the nature and extent of PFAS contamination. As a result, options to support growth will be more location-specific and tailored to the region's key industries, market demands and social drivers.

The Independent Reviewer is confident that there is a demonstrated strategic business case for a social, economic and natural capital precinct around RAAF Base Williamtown, and that implementation of this strategic business case can commence immediately. For Swartz Barracks and RAAF Base Tindal, there is a sufficient policy basis to commence development of strategic business cases for a social, economic and natural capital precinct around each site.

The core principles for this precinct development could serve as an example to demonstrate how such precincts could assist people and businesses impacted by PFAS contamination. A detailed explanation of these principles is provided in Aurecon's report 'Developing a Social, Economic and Natural Precinct' (Attachment D).

Community benefit

Community benefit is the primary principle and purpose for the precinct, and all solutions/ opportunities must address this principle. It seeks to focus development solutions specifically for PFAS-impacted land, and the potential to add value to property owners, communities, Indigenous Australians, and industry through social and economic drivers that are typically only available through initial government intervention.

A unique value proposition must be defined and founded in evidence-based projections. The unique value proposition will be determined with a focus on opportunities for repurposing PFAS-impacted land. This is not to be limited to traditional 'highest' value land uses.

PFAS co-existence and planning

Social, economic and natural capital precinct development should explore opportunities to assess and designate regions of the precincts where development of PFAS land is economically viable and feasible without causing adverse impacts to neighbouring communities/ regions or the environment. This will provide clarity to landowners and investors where development may be viable with no mitigation measures needed, few mitigation measures needed, or significant mitigation measures needed.

There is a risk that in pursuing PFAS co-existence, zoning and developments may inadvertently restrict future opportunities for land value uplift if remediation becomes more feasible. This requires careful consideration in master planning and development approval.

A guidance framework that enables PFAS co-existence would need to be developed, based on the level and nature of PFAS contamination, and current and future land use options. This would be based on existing PFAS management guidance documents, including the PFAS National Environmental Management Plan. It would require mapping of areas considered high risk for exposure, land uses, or impacted industries. There is a need to explore opportunities to streamline planning approval pathways for PFAS impacted land, including standardised land management processes for PFAS avoidance and co-existence.

There are illustrative examples of all levels of government working together to progress strategic precincts with streamlined planning approval pathways. The City Deals included setting a plan for the future of a city and then aligning policy and investments across all levels of government.[86] A key feature of the City Deals was the catalytic nature of infrastructure investments combined with urban governance and land use reform. Under the Urban Precincts and Partnerships Program, the Australian Government has committed $150 million over three years, commencing in 2024–2025. The program will fund both the development of precincts to facilitate planning, design and consultation, leading to business cases for investment-ready proposals, as well as a stream for the delivery of larger scale precinct projects.[87]

86 Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA), *Cities*, DITRDCA website. https://www.infrastructure.gov.au/territories-regions-cities/cities

87 DITRDCA, *Urban Precincts and Partnerships Program*, DITRDCA website. https://www.infrastructure.gov.au/territories-regions-cities/cities/urban-precincts-and-partnerships-program

Defence capability enhancement

PFAS-impacted land adjacent to Defence bases provides a unique opportunity for Defence to facilitate growth initiatives for the local region and economy. This includes investing to unlock further precinct development and undertaking investment attraction activities to stimulate demand.

Government and private sector initiatives

Exploring economic and social needs of the region to determine industries that could act as a catalyst for growth and change is a key feature of this precinct concept. It would support a review of environmental needs and requirements for the region, and an understanding of ecosystem and biodiversity needs.

Natural Asset Enhancement

Social, economic and natural capital precincts balance social equities, economic growth and environmental preservation and enhancement. Natural capital encompasses the resources and services provided by the environment. By understanding natural assets and ecosystems, precincts can serve as models for environmentally appropriate development and unlock economic opportunities such as biodiversity and nature repair, renewable energy and conservation activities such as green corridors and other protected areas.

During public hearings for this Review, a number of community representatives at Williamtown and Swartz Barracks proposed that future land uses surrounding bases could include using PFAS-impacted land for renewable energy projects, biodiversity or nature repair. The Australian Government recognises a growing demand for nature investment, and in December 2023 the Nature Repair Market Act 2023 came into effect. This may provide further opportunities for repurposing of PFAS-impacted land.[88] Opportunities to support suitable community and Indigenous environmental and cultural initiatives that are compatible with the contamination status of the land may also be explored.

Master planning of precincts

Government-led and centrally coordinated master planning helps ensure the precinct's unique value proposition is maximised and builds combined benefits that are not achievable in open market development. Master planning studies will identify constraints and opportunities in the area and, in parallel with market analysis, will determine optimal options for short, medium and long term horizons. Master plans will identify 'market failures' and opportunities for government and private sector intervention.

Governments should explore and identify streamlined development pathways, and explore opportunities to facilitate flexible rezoning processes to allow long-term development adaptation as PFAS impacts change and market factors evolve (for example, future Defence investment). Adaptable design and planning pathways should be applicable to any site or local government area.

Long-term strategic pathways

Precincts could be developed with staged rezoning and delivery plans that consider both long-term growth and demand over time, but allow for flexible land use changes. This will provide opportunities for near-term value creation with options for longer-term alterations as demand grows. Some sites may not immediately be suitable or required for their 'highest' value land use, but interim development could create value for landowners.

Alignment to broader government policy and initiatives across all levels of government

A coordinated governance framework is critical to the success of the precincts. The Australian Government could explore opportunities for intergovernmental coordination and collaboration with state/ territory and local governments on master planning and statutory planning, through the national coordinating body. This process would also clearly define the respective roles of the Commonwealth, state/ territory and local governments.

Explore government and private sector delivery and funding opportunities

It would be important to develop delivery plans and strategies for activation and implementation, evaluated and supported through the traditional business case process.

Development typologies

Three development planning types are proposed to deliver the precinct intent, with varying levels of government intervention.

- A Priority Development Zone would seek to address the highest and most strategic use of the land, and represent the development needs that support a region's strongest unique value proposition. It is important that these needs are strategically located to maximise their potential and economic contribution. In the case of Williamtown this aligns with the following market needs:
  - defence-related industries
  - aerospace industry
  - freight and logistics
  - education
  - innovation and entrepreneurial industries.

88 Department of Climate Change, Energy, the Environment and Water (DCCEEW), *Nature Repair Market*, DCCEEW website, 2024. https://www.dcceew.gov.au/environment/environmental-markets/nature-repair-market

- A Strategic Overlay Zone provides opportunities for development to occur outside the Priority Development Zone, but within PFAS-impacted land. These zones would be informed by strategic structure plans that align with the wider unique value proposition of a region and ensure congruent development and connectivity. Developers would be required to show that their development meets the strategic objectives of the structure plan and that their development is compatible with the constraints of the area.
- An Interim Zone identifies land that is heavily constrained and/ or sensitive. Land in this zone has limited but some development potential, provided it is compatible with the site constraints. It is acknowledged that some constraints may evolve with time and/ or that PFAS remediation technologies may improve. This means the categorisation of this zone could change over time. The requirements of the Strategic Overlay Zone would persist, but a smaller subset of development opportunities would apply. These areas also offer a significant opportunity for sustainable, low impact, nature-based and cultural solutions.

Next steps

The strategic business case for the establishment of a social, economic and natural capital precinct at Williamtown is well articulated in Attachment D ('Developing a Social, Economic and Natural Precinct').

It is acknowledged that there are always constraints to the implementation of a precinct. Typically, these are associated with the prohibitive cost of infrastructure provision, fragmentation of land ownership, and the lack of a clearly defined and aligned need and purpose (or unique value proposition). These issues will need to be carefully considered and resolved in detailed planning.

Significant desktop studies and evaluation have previously been undertaken as part of the Williamtown Special Activation Precinct, and they provide context to the challenges and opportunities across the site. The studies show that the site has numerous constraints, most significantly flooding, groundwater, poor ground conditions, PFAS impacts and important environmental communities. However, the presence and strategic nature of RAAF Base Williamtown and Newcastle Airport provide anchor industries and critical logistics infrastructure for the region and wider market.

The social, economic and natural capital precinct seeks to consider high value industry needs, and to leverage alternate value-add opportunities on less strategic and/ or constrained land. In this way, it seeks to co-exist with the constraints, rather than avoid them. There are varying levels of opportunity for intervention by governments including through master planning, planning enablement and investment attraction, through to catalytic infrastructure delivery and targeted property acquisition. There are similarly opportunities for private investment, acknowledging that development on less strategic sites may require market-led solutions. Providing expedited planning approval pathways and constraint mapping can act as a catalyst to support emerging industries, entrepreneurial development and nature enhancement.

Constraints such as PFAS contamination evolve over time, including through remediation or development of new technologies to safely co-exist with, or mitigate, risks. In such instances it is important that the precincts are reassessed regularly, including in the context of remediation actions and development of new remediation technologies, to ensure the best use of the sites are explored and transitioned to more productive development typologies where appropriate.

In implementing the strategic business case, the following next steps would need to be conducted through a Williamtown Working Group under the national coordinating body:

- Development and fine tuning of the supporting business case, including to explore the size and boundaries for a precinct and undertake additional studies including unique value proposition analysis, economic assessments and risk analysis. Building the supporting business case at Williamtown will require careful consideration of project risk, and in particular social licence, community acceptance and community expectations about timing and government approvals (including in the context of the cancelled Williamtown Special Activation Precinct).
- Seek opportunities to work with relevant New South Wales Government authorities, including planning, environment protection and regional, to streamline planning and development approval pathways (including support for amendments to promote streamlined pathways), and PFAS co-existence and mitigation guidelines
- Align social, economic and natural capital precinct objectives with other government and community initiatives and emerging planning and development standards.

Addressing the gap between 'where we are now' and 'where we want to be'

Recommendation 16: That the national coordinating body develop national guidance and principles that strategically consider land uses in areas of higher PFAS contamination. These principles should be made suitable for implementation through state/ territory and local government frameworks.

Recommendation 17: That the national coordinating body take immediate action to establish a Williamtown Working Group to commence implementation of the strategic business case for a social, economic and natural capital precinct around RAAF Base Williamtown.

Recommendation 18: That the Williamtown Working Group identify and implement a structure to coordinate and manage performance and maintenance of the local drainage network.

Recommendation 19: That the national coordinating body take immediate action to establish Oakey and Tindal working groups to prepare a strategic business case for social, economic and natural capital precincts around Swartz Barracks and RAAF Base Tindal.

Actions to implement:

- The national coordinating body should ensure the Williamtown Working Group is appropriately resourced to commence development and fine tuning of the supporting business case.
- The Williamtown Working Group should progress some initial maintenance and infrastructure works on the drainage network to alleviate immediate issues being experienced by property owners in the Primary Management Zone, including through assessing options for additional drainage outlets into Fullerton Cove.
- The national coordinating body should ensure the Oakey and Tindal working groups are appropriately resourced.

Attachment A: Terms of Reference

Independent Review of land uses around key Defence bases impacted by PFAS contamination

Introduction

Communities across Australia have been impacted by contamination as a consequence of legacy firefighting foam containing specific per- and poly-fluoroalkyl substances (PFAS) compounds. Certain PFAS compounds were active ingredients found in legacy firefighting foams used by Defence, and which Defence began phasing out in 2004.

Communities around Defence bases impacted by PFAS contamination have continued to feel the impact of contamination since the Defence PFAS Investigation and Management Program commenced in 2015. This includes contamination of land used for residential, commercial, industrial and agricultural purposes.

The Review

The Independent PFAS Review will consider land use options around Defence bases with a view to assisting people and businesses who have been affected by PFAS contamination.

The Review will specifically explore use and voluntary repurposing of impacted land in an equitable and efficient manner, including repurposing land adjacent to Defence facilities for industrial use, particularly for defence industry.

The Review will focus on land and communities which are significantly impacted by PFAS contamination and have had class actions settled, namely RAAF Base Williamtown (NSW), RAAF Base Tindal (NT), and the Army Aviation Centre Oakey (QLD).

The Review will seek submissions from the public and key stakeholders, and will conduct public hearings.

The Review will work in consultation with relevant Commonwealth agencies including the Department of Defence, the Department of Climate Change, Energy, the Environment and Water, and the Department of Infrastructure, Transport, Regional Development, Communications and the Arts; State/Territory and local governments; landowners; industry; and traditional owners and communities.

The Review will seek information from relevant State/Territory and local government authorities to understand how information about PFAS contamination informs planning and development.

The Review will make recommendations in relation to decision-making for land use and zoning around Defence sites impacted by PFAS contamination. The Review will inform the Government's policy options for managing the impacts of PFAS contamination.

The Review will include consideration of:

a. existing mechanisms for determining land uses in the context of PFAS environmental contamination;

b. jurisdictional considerations for making decisions about future land use within the different states and territories, including land zoning;

c. varying PFAS contamination management frameworks across different jurisdictions; and

d. the profile of potentially impacted properties, and thresholds or criteria that would trigger an assessment of land use.

The review is expected to have implications for other Commonwealth sites, including leased federal airports.

Critical Information Requirements

The Review will consider the Defence PFAS Investigation and Management Program. It will complement the Defence program focused on understanding the nature and extent of contamination, and remediation and management responses.

The Government acknowledges community concerns about broader impacts of PFAS contamination, including on health, the environment, and food sources. The Review will take into account the findings of, and avoid unnecessary duplication with, previous reviews and inquiries into PFAS contamination, where the latter are relevant to the understanding of repurposing of land adjacent to Defence bases and establishments.

Conduct of the Review

A suitably experienced and qualified Review Lead will be appointed to prepare a report for consideration by the Assistant Minister for Defence.

A final report will be provided within six months of commencing the Review.

Attachment B: Consultation

Submissions process

For the purpose of the Independent Review, a submission is the lodgement of a written statement. The statement could be a statement of fact, lived experience or opinion. Input could also be provided verbally, for example through testimony at a public hearing or other verbal representations during community consultation events.

Submissions were open for six weeks, from Monday 23 October to Sunday 3 December 2023.

Residents, property owners, Indigenous communities, local business and industry, local governments and elected representatives were invited to make a submission.

Submissions could be lodged through:

- the submission function on the dedicated Independent Review consultation website, which included options to comment, complete a survey or upload an attachment
- the interactive map on the dedicated Independent Review consultation website
- email
- post
- spoken testimony at a public hearing
- spoken representation through other consultation opportunities.

The Independent Review raised awareness of the submissions process through:

- flyer distribution in and around Defence bases with PFAS management areas (at the commencement of the submissions period)
- print and digital newspaper advertising local to Defence bases with PFAS management areas (on a weekly or fortnightly schedule)
- newspaper advertising in national or state-wide publications
- emails to the stakeholder list maintained by Defence's PFAS Investigation and Management Program
- emails to individuals who registered to receive a notification of submissions opening
- publication on the dedicated Independent Review consultation website.

95 submissions were received from a variety of stakeholders. Content of five of these submissions were outside of the Review's Terms of Reference.

Submissions by stakeholder group are outlined in Table 1. A full list of submissions is outlined in Table 2. Some names have been withheld by request, or because it was not immediately evident that permission to publish the author's name had been provided.

Table 1: Submissions received by stakeholder group

Stakeholder group	Number of written submissions received
Individuals, community groups and community organisations and associations	84
Businesses	8
Government agencies	2
Local councils	1
Total written submissions	**95**

Table 2: List of Submissions

Submission Number	Name
1	Peter Conroy
2	Name withheld
3	Cherylle Stone
4	Name withheld
5	Phillip Milde
6	Name withheld
7	Name withheld
8	Paula Thompson
9	Name withheld
10	Name withheld
11	Stacey Sinnock
12	Name withheld
13	Dale Parnell
14	Name withheld
15	Paul McCabe
16	Name withheld
17	Name withheld
18	Tracey Gourlay
19	Carole Dean
20	Name withheld
21	Wayne Kruger
22	Cameron Judson
23	Name withheld
24	Name withheld
25	Name withheld
26	Name withheld
27	Estelle Graham
28	Name withheld
29	Name withheld
30	Name withheld
31	Name withheld
32	Name withheld
33	Name withheld
34	Name withheld
35	Ross Moxey
36	Justin Wedd
37	Lindsay Clout

Submission Number	Name
38	Richard Matthews
39	Chris Meibush
40	Name withheld
41	Name withheld
42	Name withheld
43	Business name withheld
44	Business name withheld
45	David Garman
46	Graeme Boyd
47	Project Big River
48	Name withheld
49	Stewart Ashton
50	Peter Spafford
51	Name withheld
52	Name withheld
53	Business name withheld
54	Name withheld
55	Name withheld
56	Name withheld
57	Eco Network
58	Name withheld
59	Business name withheld
60	Business name withheld
61	Riverina Water
62	Name withheld
63	Port Stephens Council
64	Name withheld
65	Name withheld
66	Name withheld*
67	Name withheld*
68	Name withheld*
69	Name withheld*
70	Name withheld*
71	Name withheld*
72	Name withheld*
73	Name withheld*
74	Name withheld*

Submission Number	Name
75	Name withheld*
76	Name withheld*
77	Name withheld*
78	Name withheld*
79	David Jeffries
80	Dianne Priddle
81	Nicole Smith
82	Name withheld
83	Reannan Haswell
84	South Australian Environment Protection Authority
85	Name withheld*
86	Name withheld*
87	Name withheld*
88	Name withheld*
89	Indigenous meeting Tindal
90	Indigenous community meeting Williamtown*
91	Learning Circle Oakey*
92	Learning Circle Tindal*
93	Indigenous community meeting Oakey*
94	Learning Circle 1 Williamtown*
95	Learning Circle 2 Williamtown*

*Spoken representation at consultation. No formal submission available to publish

Public consultation process

The Terms of Reference specified that public hearings be conducted. In addition to public hearings, the Independent Reviewer wanted to give stakeholders the opportunity for two-way authentic dialogue. This was achieved by holding drop-in sessions for one-on-one conversations and learning circles.

Public consultation was concentrated for the communities around the three bases identified in the Terms of Reference - RAAF Base Williamtown, Swartz Barracks and RAAF Base Tindal.

Consultation opportunities were advertised in a similar manner to the submissions process. The following actions were undertaken for the three focus communities:

- radio advertising (Williamtown)
- additional public newspaper advertising (Williamtown and Katherine)
- local council and elected representatives sharing information on social media pages (Williamtown, Katherine)
- additional targeted emails
- attempts to reach out to local community organisations (Oakey).

Public hearings

A public hearing is a formal consultation, with witnesses coming forward to present a spoken testimony. For the Independent Review, these hearings took place in community venues.

Public hearings were scheduled for the three focus bases, and a virtual hearing which was open to stakeholders in any location. Stakeholders registered to speaker through the website, by email or by telephone. Speakers were allocated 20 minutes to speak. Extensions to this timeframe were at the discretion of the Independent Reviewer.

Interested stakeholders were welcome to observe the public hearings.

Public hearings were recorded. The recording was made available on the Independent Review consultation website.

There was limited interest in speaking at a public hearing at all three locations. In the instance of zero speakers being registered, the Secretariat reached out to registered observers. Observers were asked if they would like to speak. In the event that no observer wanted to speak, the Independent Reviewer supported a change in consultation type. Registered observers were informed the public hearing was cancelled and were instead invited to participate in a focus group-style learning circle.

This resulted in the following public hearings being cancelled, with learning circles conducted instead:

- Williamtown, 9 November 2023 10:00am-1:00pm.
- Williamtown, 9 November 2023 5:30pm-8:00pm.
- Oakey, 16 November 2023 5:30pm-8:00pm.
- Katherine, 22 November 2023 5:30pm-8:00pm.

Learning circles

Learning circles are a focus-group-style consultation. The goal of the session is to hold an authentic two-way dialogue. Stakeholders were encouraged to register their attendance at a learning circle, however it was not required.

The Independent Reviewer used this approach as it has been successful in his experience.

The conversation in the learning circle dialogue was typed during the session and displayed on a large screen, which enabled all participants to see how their input was being recorded. This allowed participants to amend the written record in real time.

Drop-in sessions and one-on-one conversations

A drop-in session is an advertised period of time when members of the community can 'drop-in' to a community venue. Drop-in sessions allowed informal conversations and the opportunity to ask questions in a relaxed environment. One-on-one conversations allowed an opportunity for people to present their issues without standing in front of a large crowd.

This type of consultation was available to anyone who wanted more information about the Review, or wanted a one-on-one conversation with the Independent Reviewer.

The Independent Reviewer and members of the Secretariat were available at drop-in sessions to answer questions. Community members were also able to book a specific time to hold a one-on-one conversation during this time.

Separate requests for meetings were sent to Traditional Owners and representatives of Indigenous communities around the three bases.

A summary of attendance by location and consultation type is in Table 3.

Stakeholder consultation

Stakeholder consultation included one-on-one meetings, and requests for information from the following stakeholder groups:

- Commonwealth agencies including to address issues in defence, health, environment, infrastructure, transport and agriculture
- state/ territory agencies, primarily environment, planning and development
- local governments
- universities
- industry.

A summary of meetings conducted by the Independent Reviewer is at Table 4.

Table 3: Summary of public consultation attendance

Location/ community	Date/ time (local)	Number of participants registered
Public hearings		
RAAF Base Williamtown Murrook Cultural Centre	CANCELLED* 9 November 2023 10am – 1pm	0 speakers 12 observers
	CANCELLED* 9 November 2023 5:30pm – 8pm	0 speakers 7 observers
Swartz Barracks Oakey Community Centre	16 November 2023 10am – 1pm	3 speakers 12 observers
	CANCELLED* 16 November 2023 5:30pm – 8pm	0
RAAF Base Tindal Katherine Town Council Civic Centre	22 November 2023 10am – 12:30pm	1 speaker 5 observers
	CANCELLED* 22 November 2023 5:30pm – 8pm	0
Virtual	29 November 2023 10am – 1pm	4 speakers 6 observers
Learning circles		
RAAF Base Williamtown Murrook Cultural Centre	9 November 2023 10am – 1pm	32
	9 November 2023 5:30pm – 8pm	12
Swartz Barracks Oakey Community Centre	16 November 2023 5:30pm-7:30pm	5 1 apology
RAAF Base Tindal Katherine Town Council Civic Centre	24 November 2023 09:30am-11:30am	3
Drop in sessions (one-on-one engagement)		
RAAF Base Williamtown Murrook Cultural Centre	9 November 2023	19
Swartz Barracks Oakey Community Centre	22 November 2023	4
RAAF Base Tindal Katherine Town Council Civic Centre	16 November 2023	4
Indigenous communities		
Worimi Local Aboriginal Land Council	10 November 2023 1:00pm-2:00pm	3
Oakey/ Toowoomba Indigenous community members	17 November 2023 2:00pm – 4:00pm	3
Dagoman/ Wardaman Elder	23 November 2023 5:30pm-6:30pm	1
Total		**115**

* Canceled as no stakeholders registered to speak. Additional learning circles/ focus group discussions were offered instead.

Table 4: Summary of meetings conducted by the Independent Reviewer as at 8 March 2024.

Note: Preliminary meetings were conducted by the Independent Reviewer prior to 20 September 2023.

Stakeholder group	Meeting type	Date/ time (local)
Commonwealth agencies	In person	9 August 2023 3:30pm-4:00pm
Commonwealth agencies	In person	16 August 2023 11:00am-11:30am
State/ territory agencies	In person	22 August 2023 3:00pm-4:00pm
Commonwealth agencies	In person	23 August 2023 12:00pm-1:00pm
Commonwealth Ministers	In person	23 August 2023 2:00pm-3:00pm
State/ territory agencies	In person	28 August 2023 3:30pm-4:00pm
Local government	In person	29 August 2023 11:00am-11:30am
State/ territory agencies	Virtual	6 September 2023 4:00pm-4:30pm
Federal, state/ territory and locally elected representatives	In person	6 September 2023 9:30am-10:00am
Federal, state/ territory and locally elected representatives	In person	6 September 2023 10:30am-11:00am
Commonwealth agencies	In person	6 September 2023 2:00pm-3:00pm
Federal, state/ territory and locally elected representatives	In person	7 September 2023 10:00am-10:45am
Federal, state/ territory and locally elected representatives	In person	7 September 2023 12:00pm-12:15pm
Commonwealth Ministers	In person	7 September 2023 10:45am-11:30am
Educational institution	In person	7 September 2023 7:00pm-9:00pm
Federal, state/ territory and locally elected representatives, Local government	In person	8 September 2023 9:00am-10:00am
Industry	In person	8 September 2023 11:15am-12:15pm
Industry	In person	8 September 2023 2:30pm-3:30pm
Commonwealth Ministers	In person	13 September 2023 4:00pm-4:45pm
Community	In person	20 September 2023 10:45am-12:15pm
Commonwealth agencies	In person	20 September 2023 1:15pm-1:45pm
State/ territory agencies	Virtual	21 September 2023 12:00pm-12:30pm

Stakeholder group	Meeting type	Date/ time (local)
Commonwealth agencies	Virtual	21 September 2023 2:30pm-3:30pm
Commonwealth agencies	In person	28 September 2023 4:30pm-5:00pm
Commonwealth Ministers	Virtual	28 September 2023 3:30pm-3:50pm
Federal, state/ territory and locally elected representatives	Virtual	4 October 2023 9:30am-10:50am
Commonwealth agencies	In person	4 October 2023 10:30am-11:00am
Local government	In person	4 October 2023 1:00pm-2:00pm
State/ territory agencies	In person	5 October 2023 10:30am-11:00am
State/ territory agencies	In person	5 October 2023 11:15am-12:00pm
State/ territory agencies	In person	5 October 2023 1:00pm-2:00pm
Educational institution	In person	5 October 2023 3:30pm-4:30pm
Commonwealth Ministers	In person	6 October 2023 8:00am-9:30am
Commonwealth Ministers	Virtual	6 October 2023 11:30am-12:30pm
State/ territory agencies	In person	6 October 2023 10:00am-11:00am
State/ territory agencies	In person	6 October 2023 2:30pm-3:30pm
State/ territory Ministers	Virtual	11 October 2023 2:00pm-2:30pm
Commonwealth agencies	In person	12 October 2023 10:30am-11:00am
Commonwealth agencies	In person	13 October 2023 9:00am-10:00am
Federal, state/ territory and locally elected representatives	In person	13 October 2023 3:00pm-4:00pm
Commonwealth Ministers	In person	19 October 2023 12:00pm-12:30pm
Educational institution	Virtual	25 October 2023 10:00am-11:30am
State/ territory agencies	In person	25 October 2023 12:30pm-1:30pm
Commonwealth Ministers	Virtual	25 October 2023 3:30pm-4:30pm
Commonwealth agencies	In person	26 October 2023 1:00pm-2:00pm

Stakeholder group	Meeting type	Date/ time (local)
Federal, state/ territory and locally elected representatives	In person	26 October 2023 2:45pm-3:15pm
Commonwealth agencies	In person	26 October 2023 4:00pm-4:30pm
Federal, state/ territory and locally elected representatives	In person	27 October 2023 11:00am-12:00pm
State/ territory agencies	Virtual	27 October 2023 3:30pm-4:00pm
Other stakeholders	Virtual	1 November 2023 10:00am-11:00am
Federal, state/ territory and locally elected representatives	In person	1 November 2023 2:00pm-3:00pm
Commonwealth agencies	In person	2 November 2023 10:30am-12:30pm
State/ territory Ministers	Virtual	2 November 2023 4:00pm-4:30pm
Industry	Virtual	2 November 2023 4:45pm-5:15pm
State/ territory agencies	In person	3 November 2023 10:00am-11:00am
Educational institution	Virtual	3 November 2023 12:00pm-1:00pm
State/ territory agencies	In person	3 November 2023 2:30pm-4:30pm
Commonwealth Ministers	Virtual	6 November 2023 3:00pm-4:00pm
Industry	In person	10 November 2023 10:00am-11:30am
State/ territory agencies	Virtual	23 November 2023 12:00pm-1:00pm
Commonwealth Ministers	Virtual	23 November 2023 4:30pm-5:30pm
Commonwealth Ministers	In person	29 November 2023 4:30pm-5:30pm
Federal, state/ territory and locally elected representatives	In person	30 November 2023 11:30am-12:00pm
Commonwealth agencies	In person	30 November 2023 2:00pm-3:00pm
Federal, state/ territory and locally elected representatives, Local government	Virtual	30 November 2023 3:30pm-4:30pm
Educational institution	In person	1 December 2023 1:00pm-3:00pm
Commonwealth agencies	Virtual	12 December 2023 4:30pm-5:00pm
Commonwealth Ministers	Virtual	13 December 2023 4:00pm-5:00pm

Stakeholder group	Meeting type	Date/ time (local)
Industry	Virtual	13 December 2023 12:00pm-1:00pm
State/ territory agencies	Virtual	11 January 2024 12:00pm-1:00pm
Commonwealth agencies	In person	17 January 2024 10:00am-11:00am
Commonwealth agencies	In person and Virtual	18 January 2024 3:00pm-4:00pm
State/ territory agencies	Virtual	24 January 2024 4:30pm-5:30pm
Commonwealth Ministers	In person	24 January 2024 2:15pm-3:15pm
Commonwealth Ministers	In person	25 January 2024 10:15am-11:00am
State/ territory agencies	Virtual	25 January 2024 11:30am-12:30pm
Federal, state/ territory and locally elected representatives	Virtual	25 January 2024 3:00pm-4:00pm
Local government	Virtual	31 January 2024 9:00am-10:00am
Federal, state/ territory and locally elected representatives	Virtual	31 January 2024 1:00pm-2:00pm
Commonwealth agencies	Virtual	31 January 2024 4:00pm-5:00pm
Commonwealth agencies	In person	1 February 2024 9:30am-10:30am
Federal, state/ territory and locally elected representatives	Virtual	2 February 2024 1:00pm-2:00pm
State/ territory agencies	Virtual	2 February 2024 2:30pm-3:30pm
Federal, state/ territory and locally elected representatives	Virtual	7 February 2024 11:30am-12:30pm
Federal, state/ territory and locally elected representatives	Virtual	7 February 2024 1:00pm-2:00pm
Federal, state/ territory and locally elected representatives	Virtual	7 February 2024 10:00am-11:00am
Federal, state/ territory and locally elected representatives	In person	8 February 2024 12:30pm-1:30pm
Federal, state/ territory and locally elected representatives	In person	9 February 2024 10:00am-11:00am
Commonwealth Ministers	In person	15 February 2024 11:00am-11:45am
Commonwealth Ministers	In person	15 February 2024 12:00pm-12:30pm
Commonwealth agencies	In person	15 February 2024 2:30pm-3:00pm

Stakeholder group	Meeting type	Date/ time (local)
Commonwealth agencies	In person	16 February 2024 9:30am-10:00am
State/ territory agencies	Virtual	16 February 2024 10:30am-11:30am
State/ territory agencies	Virtual	20 February 2024 5:00pm-5:30pm
Commonwealth agencies	Virtual	21 February 2024 9:00am-9:30am
Commonwealth agencies	Virtual	26 February 2024 5:00pm-5:30pm
State/ territory agencies	Virtual	27 February 2024 4:00pm-5:00pm
Commonwealth Ministers – Advisors	Virtual	28 February 2024 9:00am-9:30am
Commonwealth Ministers - Advisors	In person	28 February 2024 9:45am-10:15am
Federal, state/ territory and locally elected representatives	Virtual	28 February 2024 1:00pm-1:45pm
Commonwealth Ministers - Advisors	Virtual	28 February 2024 2:00pm-3:00pm
Commonwealth Ministers	Virtual	28 February 2024 4:30pm-5:00pm
Commonwealth agencies	Virtual	6 March 2024 9:30am-10:00am
Federal, state/ territory and locally elected representatives - Advisors	Virtual	6 March 2024 11:00am-11:30am
Commonwealth Ministers	Virtual	7 March 2024 3:30pm-3:50pm
Commonwealth Ministers	In person	8 March 2024 11:30am-1:00pm
State Ministers - Advisors	In person	8 March 2024 2:30pm-3:00pm
Total		**107**

Attachment C: PFAS Rapid Review

Australian National University

PFAS Rapid Review

A rapid review of national and international health advice on the impacts of human exposure to per- and polyfluoroalkyl substances (PFAS)

A report prepared for the Australian Government PFAS Independent Review of land uses around key Defence sites impacted by PFAS contamination.

18 January 2024

TEQSA Provider ID: PRV12002 (Australian University) | CRICOS Provider Code: 00120C

Report prepared by Dr Kayla S Smurthwaite, Dr Scott Crerar, Susan Trevenar, Rose Hosking, and Professor Martyn D Kirk.

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CRICOS Provider Code: 00120C

We acknowledge Professor Bruce Armstrong and Claudia Goodman for providing valuable contributions to the review of international literature included in the rapid review. We acknowledge Danielle Cribb for providing editorial support for this rapid review.

The Australian National University acknowledges, celebrates, and pays our respects to the Ngunnawal and Ngambri people of the Canberra region and to all First Nations Australians on whose traditional lands we meet and work, and whose cultures are among the oldest continuing cultures in human history.

Contents

Executive Summary

Globally, governments have provided advice and initiated public health actions to limit human exposure to PFAS, particularly in communities impacted by local environmental contamination. Over the past decade, public health agencies worldwide have responded to concern about local environmental contamination of PFAS, producing health guidelines and programs to monitor human exposure.

In Australia, contamination of residential areas around certain Australian Defence Force bases resulted in human exposure to PFAS. This contamination led to significant concern in communities and response from government. The health impacts and extent of these exposures were investigated in the PFAS Health Study. In September 2023, the Australian Government established an Independent Review of land use in these areas. The Independent Review commissioned the Australian National University (ANU) to conduct a rapid review of current national and international public health advice and human Health Based Guidance Values (HBGV) for PFAS published by agencies across Australia, the European Union (EU) and the United States (US), and systematic reviews of the effects associated with human exposure to PFAS published in the past five years.

This rapid review of literature and health guidance was conducted in accordance with the World Health Organization (WHO) Rapid Reviews to Strengthen Health Policy and Systems Practical Guide.

Public Health Advice for Human Exposure to PFAS

Public health advice for PFAS in Australia, the EU, and the US is largely consistent in the way that the potential health effects associated with human exposure to PFAS are reported. However, there are several important differences across key documents from health and environmental agencies.

Based on our search of scientific databases, we identified 99 reviews, including systematic reviews, meta-analyses, and scoping reviews, published in the past five years that reported on the evidence of human health effects associated with PFAS. Although there are many scientific publications, notably systematic reviews, that have reported associations between health effects and PFAS in recent years, many of them represent a re-evaluation of previous key or pivotal studies. They do not necessarily represent significant advances in the scientific evidence base around PFAS and health effects. In this rapid review, we discuss evidence from reviews related to adverse health outcomes referred to in public health advice.

In Australia, public health advice for PFAS does not report cancer as a potential adverse health effect associated with human exposure. The public health advice for the EU and the US concludes evidence of increases in the risk of kidney and testicular cancer associated with increases in human exposure to PFAS, with specific reference to epidemiological associations observed in highly exposed populations. Key documentation for public health advice across Australia, the EU and the US references the International Agency for Research on Cancer (IARC) 2016 Monograph on PFOA, which categorised PFOA as a Group 2B Carcinogen i.e., possibly carcinogenic to humans, based on limited evidence available for kidney and testicular cancer. In 2023, IARC re-classified PFOA as carcinogenic to humans, based on sufficient animal cancer evidence and strong mechanistic evidence for humans, and PFOS as possibly carcinogenic based on strong mechanistic evidence. Due to the recency of this classification, it is not currently included in public health advice for human exposure to PFAS across Australia, the EU and the US. It is important to note that the IARC does not consider dose or exposure measures in their findings on carcinogenicity, and therefore, does not advise any indications of the health risks posed to communities impacted by environmental contamination or occupational cohorts. We identified three recent systematic reviews on PFAS and cancer that support kidney and testicular cancer as potential health outcomes associated with PFAS exposure.

Public health advice for PFAS across Australia, the EU and the US all reference potential adverse immunological outcomes associated with human exposure to PFAS, specifically lowered antibody responses following vaccination. As a basis for conclusions of the carcinogenicity of PFOA and PFOS, the IARC reported strong mechanistic evidence for immunosuppression. We identified five systematic reviews that report associations of PFAS and decreases in immune function that supports public health advice across Australia, the EU and the US.

Advice regarding conclusions on the effects of PFAS on human biomarkers, such as those relating to thyroid hormones, liver damage and kidney function, were inconsistent across regions. In recent systematic reviews there appear to be some evidence for potential effects. For maternal health and birth outcomes, the advice across countries was relatively consistent for potential health effects, although there was inconsistency for some effects, such as pregnancy induced hypertension or pre-eclampsia.

Human Health Based Guidance Values for PFAS

National and international agencies have established HBGV for a range of substances that occur in food and/or water such as pesticides, contaminants and toxins. A HBGV can then be

used to recommend standards and other risk management measures to decrease exposure to the substance and to protect public health.

In Australia, Food Standards Australia New Zealand (FSANZ) developed the HBGV for PFAS using data from animal studies for toxic endpoints. Pharmacokinetic modelling and safety factors were then applied to derive the amounts of PFAS considered safe to consume over a lifetime. This methodology is considered a sound approach in the absence of appropriate high-quality human studies. Other European countries and Canada have also utilised this approach and have HBGV similar in magnitude to Australia.

In contrast, both the United States Environmental Protection Agency (USEPA) and European Food Safety Agency (EFSA) used human epidemiological studies to establish endpoints on which to base their HBGV. The USEPA and EFSA chose a decreased antibody response to vaccines in humans as the most sensitive endpoint. This approach has resulted in significantly lower values for PFAS HBGV compared to those established in Australia and elsewhere. Lower HBGV are not necessarily more protective of public health if endpoints on which they are established come from studies with limitations and adverse effects have questionable clinical significance. The use of observational human epidemiological studies presents several limitations including difficulties in clearly defining an exposure, the possibility of confounding, and an inability to demonstrate causality. In its report on PFAS HBGV in 2017, and its subsequent review of the evidence around PFAS and immunotoxicity in 2021, FSANZ considered that it was inappropriate to base PFAS HBGV on the available human epidemiological studies that looked at immune effects.

1 Introduction

Per- and polyfluoroalkyl substances (PFAS) are a large group of fluorinated chemicals that were first developed for commercial use in the 1940s (Buck et al, 2011). They have been used in an extensive range of common household and personal products, in addition to industrial applications, including aqueous film-forming foams (AFFF) used to extinguish liquid fuel fires in aviation settings (Buck et al, 2011). Since the early 2000s, PFAS have been extensively studied in relation to the potential health effects and environmental risks. Perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS) and perfluorohexane sulfonic acid (PFHxS) are the most widely studied PFAS. These PFAS (referred to as legacy PFAS) are ubiquitous in the environment, resistant to environmental degradation and bioaccumulative in wildlife and humans, with an estimated half-life in humans of 2–8 years (Agency for Toxic Substances and Disease Registry, 2021b; Buck et al, 2011; Li et al, 2018; Olsen et al, 2007; Xu et al, 2020).

Globally, health and environmental agencies have provided advice and initiated public health actions to limit exposure to PFAS within the general population and occupational cohorts through changes to the production and use of PFAS. Most measures to reduce human exposure have centred on communities impacted by local environmental contamination associated with the production and use of PFAS. Generally, people who live or work in these contaminated areas are provided with public health advice about potential exposure pathways and relevant precautions, along with the potential human health effects of PFAS. Over the past decade, public health agencies worldwide have responded to concern of local environmental contamination of PFAS, producing health guidelines and programs to monitor human exposure through the measurement of PFAS concentrations in human blood and environmental sources, such as water and soil.

1.1 Australian Government Independent Review

In September 2023, the Australian Government established an Independent Review of land use in residential areas around certain Australian Defence Force bases impacted by local environmental contamination of PFAS — the Royal Australian Air Force (RAAF) Bases at Tindal in Katherine, Northern Territory (NT) and Williamtown in New South Wales (NSW) and Swartz Barracks (formerly the Army Aviation Centre) in Oakey in Queensland (Qld). The exposure to PFAS and the potential health effects in these communities was previously investigated in the PFAS Health Study (pfas.anu.edu.au) — an epidemiological study commissioned by the Australian Government Department of Health and Aged Care (DoHAC), formerly the Department of Health. The Independent Review, led by Mr Jim Varghese AM, seeks to investigate potential

avenues for land use in the PFAS-contaminated areas and to consider equitable and effective pathways forward for people who live and work within these communities, including the potential to repurpose land in proximity to the Defence Force bases. Detailed information on the Terms of Reference for the Independent Review is available at https://www.pfasindependentreview.com.au/pfasreview/page/home.

1.1.1 Australian National University (ANU) Rapid Review of Human Health Guidance

Following consultation with members of the PFAS Health Study team from the ANU in November 2023, the Independent Review commissioned the ANU to conduct a rapid review of national and international health guidance for human exposure to PFAS as technical advice to Mr Jim Varghese AM. The rapid review addresses two objectives.

1. To outline and compare the public health advice on PFAS in Australia, the European Union (EU) and the United States (US), including the context of exposure to PFAS in each location, and discuss the key epidemiological evidence published in the past five-years, with a focus on high-quality evidence from systematic reviews.
2. To outline and compare the human Health Based Guidance Values (HBGV) for PFAS in Australia, the EU, and the US, including the methodology used to derive them, the key numbers such as the Tolerable Daily Intake (TDI), or equivalents and critical health endpoints used in each region.

2 Methodology

We conducted a rapid review of current national and international public health advice and HBGV for PFAS published by agencies across Australia, the EU and the US, and systematic reviews of the health effects associated with human exposure to PFAS published in the past five years. We conducted this search between 7–20 December 2023.

The rapid literature review was conducted in accordance with the World Health Organization (WHO) Rapid Reviews to Strengthen Health Policy and Systems: A Practical Guide, henceforth called the WHO Rapid Reviews Guide (Alliance for Health Policy and Systems Research SCI, 2017). The methodological approach for the rapid review was semi-systematic. Notably, we did not seek to assess all available research and data in the review. The review excluded guidelines that were derived from HBGV, such as drinking water guidelines and biosolids guidelines. Further, the scope of the rapid review excluded evidence that we had previously reviewed in the ANU PFAS Health Study Systematic Review commissioned by DoHAC in 2016–2018, as the intent was to capture relevant new evidence published since that time.

2.1 Scientific Database and Grey Literature Search Strategy

We developed a search strategy approach to capture peer-reviewed systematic review publications on a scientific literature database, and grey literature publications on key national and international health agency websites.

To identify peer-reviewed systematic reviews published following the ANU PFAS Health Study Systematic Review, we developed a search strategy based on relevant medical subject headings (MeSH) and publication terms and restricted the search strategy to publications from 8 February 2017, capturing publications not previously included in search strategy for the PFAS Health Study Systematic Review.

- Fluorocarbon [MeSH Term], incorporating Per- and Polyfluoroalkyl Substances, Per and Polyfluoroalkyl Substances, PFAS.
- Meta-Analysis [Publication Type]
- Systematic Review [Publication Type]
- Review [Publication Type]

The search strategy included research articles available on the PubMed (including Medline) scientific database, based on an advanced search function. The search strategy for the PubMed database was as follows:

(Meta-Analysis[Publication Type] OR Systematic Review[Publication Type] OR Review[Publication Type]) AND (Fluorocarbon[MeSH Terms]) AND (2017/2/8:2023/12/7[pdat]).

We adapted the search strategy to search grey literature sources, including health institution websites, for published health guidance for human exposure to PFAS. The review included publicly available, national and regional-level grey literature publications in English only, in addition to sub-national level grey literature publications related to the Australian State and Territory jurisdictions for the Australian Defence Force bases under investigation in the Independent Review i.e., NSW, NT and Qld. We did not restrict the review of grey literature sources by date to capture the most recent available human health guidance for PFAS, which was not previously reviewed in the PFAS Health Study systematic review.

The rapid review included reports and lay language resources e.g., fact sheets, frequently asked questions, and infographic materials, available through the following grey literature sources, based on a keyword search function only i.e., PFAS and/or per- and polyfluoroalkyl substances:

- Australian Government PFAS Taskforce, henceforth called the PFAS Taskforce
- DoHAC, including Expert Health Panel for PFAS and Environmental Health Standing Committee (enHealth) of the Australian Health Protection Principal Committee (AHPPC)
- Food Standards Australia and New Zealand (FSANZ)
- NSW Health
- NSW Environmental Protection Authority
- NT Food Safety
- NT Environmental Protection Authority
- Qld Health
- Qld Department of Environment, Land and Water
- US Centers for Disease Control and Prevention (CDC), including the Agency for Toxic Substance and Disease Registry (ATSDR)
- US Environmental Protection Agency (USEPA)
- American Cancer Society
- European Commission Energy, Climate Change and Environment
- European Environmental Agency (EEA)
- European Food Safety Authority (EFSA)
- Swedish Chemicals Agency (KEMI)
- German Environment Agency (Umweltbundesamt)
- Danish Environmental Protection Agency (Danish EPA)
- United Nations Environment Programme Stockholm Convention

- WHO International Agency for Research on Cancer (IARC)
- Organisation for Economic Co-operation and Development (OECD) Portal on Per and Poly Fluorinated Chemicals

Under a staged search strategy approach, following the identification of relevant systematic reviews, we identified studies with alternative study design (i.e., primary research publications) to provide additional evidence to support the rapid review objectives. We restricted the search of primary research publications to research cited in the systematic reviews and grey literature eligible for inclusion in the rapid review.

2.2 Literature Screening, Selection and Synthesis

We conducted screening and extraction in accordance with the WHO Rapid Reviews Guide (Alliance for Health Policy and Systems Research SCI, 2017). The scientific database and grey literature searches were conducted by one reviewer (KS) with support from four additional reviewers (SC, ST, RH and CA) to review search results and identify key publications for inclusion in the rapid review.

Initial screening of articles identified in the scientific database search was conducted by one reviewer (KS) at the title and abstract level and subsequently verified by a second reviewer (ST), with discrepancies discussed and resolved between the two reviewers. Two reviewers (ST and RH) extracted data and summarised the content of articles identified in the scientific database search. A third reviewer (KS) checked a random sample of 10% of the data extractions for accuracy as a quality assurance measure for the rapid review. Four reviewers (KS, SC, ST and CA) extracted data and summarised the content of publications identified in the grey literature search and a fifth reviewer (RH) checked the data extractions for accuracy.

Data extraction procedures included the collection and summary of qualitative and quantitative data content included in the peer-reviewed and grey literature publications, after establishing eligibility for the inclusion in the rapid review. We conducted a qualitative synthesis consisting of a narrative summary of the findings across articles, identifying common themes, patterns, and discrepancies across publications. The rapid review did not include formal quality assessment of risk of bias for the peer-reviewed and grey literature publications.

3 Public Health Advice for Human Exposure to PFAS

Studies of human exposure to PFAS indicate a range of potential impacts across the lifespan, including adverse effects on metabolism and endocrine function, immunity, reproduction and development (Agency for Toxic Substances and Disease Registry, 2021b; Fenton et al, 2021; Kirk et al, 2018; Sunderland et al, 2019). However, despite extensive epidemiological and toxicological studies of exposure to PFAS, the human health effects have not yet been fully elucidated and causation has not been established. Globally, public health advice takes cautious approaches to control human exposure to PFAS, due to the ongoing exposure to these persistent pollutants and the uncertainty of the human health impacts associated with different levels of exposure to PFAS. In this section, we outline and compare the public health advice for PFAS in Australia, the EU, and the US, including the context of exposure to PFAS in each location, and discuss the key epidemiological evidence published in the past five years, with a focus on high-quality evidence from systematic reviews.

3.1 Summary of National and International Public Health Advice for PFAS

A summary of public health advice for PFAS in Australia, the EU, and the US with a description of the listed adverse human health effects is shown in Table 1.

Table 1. Summary table for public health advice for PFAS in Australia, the EU, and the US.

	Australia	EU	US
	DoHAC	EEA	CDC ATSDR
Cholesterol levels	✓	✓	✓
Indicators of kidney function	✓		
Indicators of liver damage		✓	✓
Indicators of immune response	✓	✓	✓
Thyroid and/or sex hormone levels	✓	✓	
Cancers		✓	✓
Maternal and birth outcomes	✓	✓	✓
Onset of puberty	✓		

Inclusion of a tick symbol indicates that the public health advice for the region refers to the potential association of the adverse health outcome and human exposure to PFAS, which may include increases or decreases in an associated measure of health.

3.2 Evidence Base for National and International Public Health Advice on PFAS

3.2.1 Australia

Public health advice for PFAS in Australia is in response to community exposure to PFAS from environmental contamination. The guidance has a central focus on people that live or work in areas surrounding Defence Force bases with contamination of land and water sources from historic use of AFFF for aviation firefighting.

Nature of Exposure to PFAS in Australia

Across the key residential areas surrounding Defence Force bases affected by PFAS environmental contamination — the Australian Government Department of Defence, henceforth called the Department of Defence, PFAS Management Areas at Katherine in the NT, Oakey in Qld, and Williamtown in NSW — means of blood serum concentrations for people who had ever

lived or worked in the areas ranged from 4.9–6.6 nanograms per millilitre (ng/mL) for PFOS and from 2.9–3.7 ng/mL for PFHxS in 2016–2019, with 29–42% of people having an elevated serum PFOS concentration and 48–55% an elevated serum PFHxS concentration above background serum concentrations measured in comparison communities (with no environmental contamination of PFAS) (Smurthwaite et al, 2021). Means of serum PFOA concentrations ranged from 1.3–1.8 ng/mL for people from Katherine, Oakey, and Williamtown, which was similar to that observed in residents of comparison communities (Smurthwaite et al, 2021). This exposure profile of blood serum PFAS concentrations is consistent with PFOS and PFHxS as the main constituents of AFFF used on Defence Force bases and the predominant PFAS measured in sampling of land and water sources (Smurthwaite et al, 2021).

Current estimates of background levels of PFAS in the Australian general population are based on the 95th percentile for PFOA and PFOS from the Australian general population across age categories, measured by pooling of pathology sampling in a Southeast Queensland population in 2011–2012 (Smurthwaite et al, 2021). These estimates were the most recent measures of blood serum PFAS concentrations for PFAS in the general population when the Australian Government established a national blood testing program for PFAS in areas impacted by environmental contamination. The Australian Bureau of Statistics National Health Measures Survey 2022 will provide the first assessment of background exposure to PFAS in a nationally representative sample of the Australian general population (Australian Bureau of Statistics, 2022).

Human biomonitoring studies using pooled blood serum samples of the Australian population have shown consistent declines in serum PFOS, PFHxS and PFOA concentrations over the past two-decades, with continued monitoring of change in blood serum PFAS concentrations in people who have lived or worked in the PFAS Management Areas (Toms et al, 2019; Toms et al, 2014).

Public Health Advice regarding PFAS from DoHAC

Advice on PFAS as a hazard to human health, such as information on the potential adverse health effects associated with exposure to PFAS and recommendations for blood testing for PFAS have been prepared by DoHAC and relevant committees and advisory bodies. Information resources on human health provided by state and territory governments include direct reference to statements by DoHAC.

In 2016, the AHPPC provided the first public health advice for PFAS in Australia, following publication of the Department of Defence PFAS Management Areas at Oakey in Qld and Williamtown in NSW. The AHPPC is the principal public health decision making committee in

Australia and comprises all Chief Health Officers of Departments of Health at the federal and state and territory levels, along with other national agencies and experts. In 2017, enHealth — one of AHPPC's sub-committees — released Interim Guidance Statements on the public health risk associated with PFOA, PFOS and PFHxS for human exposure pathways from environmental contamination. In 2019, enHealth updated the Guidance Statements on PFAS in Australia outlining the public health advice, following an independent review of epidemiological and toxicological evidence for human exposure to PFAS by an Expert Health Panel for PFAS convened by DoHAC (Buckley et al, 2018; Environmental Health Standing Committee (enHealth), 2019). The final report prepared by the Expert Health Panel in providing advice to the Australian Government Minister of Health in 2018 is the current basis of public health advice for PFAS in Australia (Buckley et al, 2018). A summary of the enHealth Guidance Statements on PFAS and the Expert Health Panel report is available in Appendix A (annotated reference I and II, respectively).

The enHealth Guidance Statements on PFAS report the following adverse health effects associated with human exposure to PFAS, based on the consistency of scientific evidence reported in systematic reviews and grey literature sources:

- Increases in cholesterol levels.
- Increases in uric acid levels.
- Decreases in kidney function.
- Change in indicators of immune response (following vaccination).
- Change in thyroid and sex hormone levels.
- Increases in age that menstruation starts in girls and earlier menopause.
- Decreases in birth weight in babies.

Notably, the enHealth Guidance Statements differentiate between associations of adverse health effects and human exposure to PFAS and causation, with conclusions that there was no evidence that PFAS causes human disease in the Expert Health Panel report. The Guidance Statements clarify that:

> *"The health effects reported in these associations are generally small and within normal ranges for the whole population. There is also limited to no evidence of human disease or other clinically significant harm resulting from PFAS exposure… However, the weaknesses in the scientific evidence mean that whilst early indications suggest that PFAS exposure has a minimal impact on human health, we also cannot definitively rule out other important health effects".*

The enHealth Guidance Statements recognise that the absence of sufficient evidence of a link between PFAS and adverse health outcomes does not equate to no evidence of potential adverse health effects immediately or in the future. The Guidance Statements refer to minimisation of exposure whilst uncertainty remains, and further research is undertaken. Accordingly, the Guidance Statements include recommendations to follow local state and territory information on the precautions to reduce exposure to PFAS for people who live or work in communities affected by environmental contamination, with specific reference to ingestion of contaminated food and water as the primary exposure pathways for PFAS. In particular, the Guidance Statements identify pregnant women as a sensitive population for PFAS, advising to minimise their potential exposure to PFAS due to the transfer of PFAS from mother to foetus through the placenta during pregnancy. However, the Guidance Statements recommend that mothers breastfeed infants, despite transfer of PFAS form mother to infant through breastmilk, due to the well-established benefits of breastfeeding for maternal and child health.

The enHealth Guidance Statements do not recommend blood testing for PFAS for the purpose of health screening or clinical intervention. The Guidance Statements outline the limitations of individual blood testing for PFAS, including the inability to determine any potential changes in health status for an individual in relation to their exposure to PFAS. Blood testing for PFAS is considered beneficial to investigate population-level exposure to PFAS in a research setting, particularly to determine the effectiveness of exposure control measures to reduce exposure to PFAS. However, the enHealth Guidance Statements advise against repeated individual blood testing for PFAS due to the half-life of PFAS i.e., the expected time period required to observe a decrease in blood serum PFAS concentrations in an individual.

Broader information on public health advice for PFAS from DoHAC has referenced the PFAS Health Study as a key epidemiological study that assessed exposure to PFAS, along with the potential health effects, among people who had lived or worked in the PFAS Management Areas of Katherine, Oakey and Williamtown. Information referred to how to participate in the study (throughout the study period) and the final findings of the epidemiological study.

Other Information Sources for Public Health Advice for PFAS in Australia

The PFAS Taskforce acts as a national coordinating body for the intergovernmental response to environmental contamination of PFAS across key agencies, such as DoHAC, the Department of Climate Change, Energy, the Environment and Water, and the Department of Defence, and to provide updated information on national advice for PFAS on environmental and human health-related information through a central website (https://www.pfas.gov.au/).

Advice on the control of human exposure to PFAS for communities impacted by local environmental contamination, such as information on the recommendations for precautions to reduce potential exposure to PFAS, is under the provision of the relevant state and territory governments. Resources reference the need for these measures due to limited or insufficient information on the human health risks associated with PFAS, as outlined by DoHAC (Environmental Health Standing Committee (enHealth), 2019; New South Wales Environment Protection Authority, 2023; New South Wales Health, 2017; Northern Territory Environment Protection Authority, 2023; Northern Territory food safety and regulations, 2018; Queensland Government Department of Environment; Queensland Health, 2018). A summary of key grey literature sources for each state and territory government department is available in Appendix A (annotated references V–X).

3.2.2 European Union

The EU has implemented several policy initiatives to minimise human exposure to PFAS in accordance with the Stockholm Convention on persistent organic pollutants, initiated by the United Nations Environmental Programme to recognise the need for measures to control the manufacture and use of emerging environmental contaminants (United Nations Environment Programme, 2019). A summary of the Stockholm Convention on persistent organic pollutants is available in Appendix A (annotated reference XI).

Public health advice for PFAS is generally limited across the EU, potentially due to publication of local advice in languages other than English. Where available, information across the EU commonly references actions towards reducing the impact of PFAS on the environment and humans, citing pollution concerns and potential chemical alternatives to PFAS. Largely, health advice responds to public concern of potential exposure to PFAS in the general population and in residential areas impacted by local environmental contamination of PFAS.

Nature of Exposure to PFAS in the EU

Across the EU, key residential areas impacted by local environmental contamination of PFAS include Veneto in Italy, Antwerp in Belgium, Dordrecht in the Netherlands, Ronneby in Sweden, and Korsør in Denmark. Two significant epidemiological studies have been established in two affected areas — a public health surveillance program in the Veneto region of Italy and a cohort study of residents in Ronneby, Sweden.

In the Veneto region, median blood serum concentrations were 14 ng/g for PFOA, 8.7 ng/g for PFOS and 3 ng/g for PFHxS for residents exposed to contaminated drinking water sources from a local PFOA manufacturing facility, equivalent to eight times as high as residents of

surrounding areas not affected by local environmental contamination of PFAS (Ingelido et al, 2020). For local farmers in the Veneto region, median blood serum concentrations were 40 ng/g for PFOA, 12 ng/g for PFOS and 4.5 ng/g for PFHxS (Ingelido et al, 2020).

In Ronneby, median blood serum concentrations for people who lived in areas with a contaminated reticulated (town) water supply from AFFF use at a local military base were 135 ng/mL for PFOS, 114 ng/mL for PFHxS, and 6.8 ng/mL for PFOA (Xu et al, 2021). Median blood serum concentrations for residents of Ronneby were 35 times as high as residents of a comparison community for PFOS and 135 times as high for PFHxS (Xu et al, 2021).

The European Human Biomonitoring Initiative (HBM4EU) aims to measure human exposure to chemicals across the EU to inform policy decision-making related to exposure to and the health risks for three age groups: children (6–11 years), teenagers (12–19 years) and adults (20–39 years) (Human Biomonitoring for Europe (HBM4EU), 2016; Richterová et al, 2023). Blood serum PFAS concentrations were measured in teenagers through the HBM4EU to provide information on background levels of exposure to PFAS in the general population. Means of blood serum concentrations for teenagers from nine European countries were 2.13 μg/L for PFOS, 0.97 μg/L for PFOA, 0.41 μg/L for PFHxS and 0.30 μg/L for perfluorononanoic acid (PFNA) (Richterová et al, 2023).

Public Health Advice regarding PFAS from the EEA and National Health Agencies

Advice on the potential human health and environmental risks for PFAS for the EU is outlined by the EEA, with emphasis that currently there is no comprehensive risk assessment for human health for the EU due to the complexity of assessing the variation in the types and level of PFAS exposure across the region (European Environmental Agency, 2019). Further, the EEA reports that a risk assessment for individual PFAS is not suitable for decision-making to reduce potential risks to human health due to the exposure to PFAS as a mixture with potential for interactions, rather than as a single chemical (European Environmental Agency, 2019). In the absence of consolidated information and conclusions for human health, the EEA advises approaches to manage exposure to PFAS and the associated risks, with specific reference to transition to the use of chemicals that are not adverse environmental pollutants (European Environmental Agency, 2019). A summary of the EEA Briefing of the Emerging Chemical Risks in Europe for PFAS is available in Appendix A (annotated reference XII).

The EEA reports high certainty for the following adverse health effects associated with human exposure to PFAS, with reference to evidence from the USEPA, WHO IARC and peer-reviewed systematic reviews for PFAS:

- Increases in cholesterol levels.
- Increases in liver damage.
- Increases in kidney and testicular cancer.
- Decreases in immune response (following vaccination).
- Increases in thyroid disease.
- Decreases in birth weight in babies.
- Delays in development of the mammary gland.

The EEA further reports the following adverse health effects associated with human exposure to PFAS, based on a lower level of certainty from peer-reviewed and grey literature sources:

- Increases in obesity.
- Decreases in the age of onset of puberty.
- Decreases in indicators of male fertility, including sperm count and mobility.
- Increases in the time-period to pregnancy.
- Increases in pregnancy induced hypertension and pre-eclampsia in pregnant women.
- Increases in breast cancer.
- Increases in ulcerative colitis (inflammatory bowel disease).

Based on the persistence of PFAS in the environment and the human body, the EEA justifies increases in the total body burden and high associated risks to human health. The EEA identifies children and elderly people as most at risk of adverse health outcomes and draws the following conclusion:

> *"Of the relatively few well-studied PFAS, most are considered moderately to highly toxic, particularly for children's development."*

The EEA does not provide recommendation for blood testing for PFAS or associated health screening. However, information is provided on the HBM4EU to measure exposure to PFAS across the EU (Human Biomonitoring for Europe (HBM4EU), 2016). Further information on exposure to and the health effects of PFAS, including exposure pathways in the general population and areas impacted by environmental contamination, are recognised in a HBM4EU factsheet on PFAS (Human Biomonitoring for Europe (HBM4EU), 2021). A summary of the HBM4EU factsheet on PFAS is available in Appendix A (annotated reference XIII). The HBM4EU reports the following adverse health effects associated with human exposure to PFAS, with reference to the EEA:

- Increases in cholesterol levels.

- Increases in liver damage.
- Increases in kidney and testicular cancer.
- Immunotoxicity, including decreases in immune response (following vaccination).
- Increases in thyroid disease.
- Developmental toxicity.
- Changes in reproduction and fertility.

The HBM4EU recommends implementation of measures to minimise potential exposure to PFAS, specifically due to the persistence of PFAS in environmental sources and the human body. The HBM4EU acknowledges the need for further research to understand the health risks associated with PFAS.

In Sweden, KEMI include a brief outline of the health effects associated with human exposure to PFAS, with the following conclusion (Swedish Chemicals Agency (Kemi), 2023):

> *"There is evidence that a few PFAS present a health hazard; for example, PFOS and PFOA, which are classified as reproductive toxins and suspected carcinogens. There is however limited knowledge of the health effects of many other PFAS…"*

KEMI reports the following additional adverse health effects associated with human exposure to PFAS, based on epidemiological studies of people who live in areas impacted by local environmental contamination.

- Increases in cholesterol levels (PFOA).
- Effects on the liver (PFOA).
- Decreases in immune response (PFOA and PFOS).
- Effects on birth weight in babies.

A summary of the KEMI Chemical Substances and Materials website for PFAS is available in Appendix A (annotated reference XIV).

The Danish EPA refers to a key report prepared in 2015 to evaluate the human health hazards for PFOA, PFOS and PFHxS to propose the HBGV to apply to drinking and ground water sources (Danish Ministry of the Environment, 2015). The Danish EPA report synthesises the toxicological and epidemiological evidence for human exposure to PFAS, with reference to animal models and mechanistic studies. A summary of the Danish EPA report is available in Appendix A (annotated reference XV). The Danish EPA reports the following adverse health effects associated with human exposure to PFAS, based on reports by the EFSA in 2008 in 2014:

- Decreases in birth weight in babies (PFOA and PFOS).
- Lower head circumference in babies (PFOA).

However, the Danish EPA report qualifies that epidemiological investigation of blood plasma concentrations of PFAS in pregnant women in Denmark did not show associations with birth weight or gestational age measurements, in contrast with the evidence available from the US. The Danish EPA reported further evidence for decreases in antibody response following tetanus vaccination associated with increases in blood serum PFAS concentrations in a study of children in Denmark, contextualising the potential health risks for the Danish population through one peer-reviewed original research article. However, overall, the Danish EPA report refers to differences in the outcomes reported by peer-reviewed primary research articles on the human health effects of PFAS and draws the following conclusions:

> *"Overall, the human data on PFOA and PFOS were by EFSA (2008) or USEPA (2014a+b) found to deliver some support to the findings in experimental animals; however, the data are considered far from adequate for making definitive conclusions on critical effects and dose-response relationships."*

The Danish EPA reports associations for the following additional adverse health effects, however, refers to inconsistencies in peer-reviewed literature, such as the magnitude of effect:

- Increases in cholesterol levels, including triglycerides.
- Changes in thyroid hormones.

As observed for the EEA advice for PFAS, the KEMI and Danish EPA also do not provide recommendation for blood testing for PFAS or associated health screening.

The German EPA webpage was published in German and therefore, not included in this rapid review. Information is available at: https://www.umweltbundesamt.de/themen/pfc-planet-chemikalien-in-der-umwelt.

3.2.3 United States

Public health advice for PFAS in the US aims to assist local, state and federal-based stakeholders in responding to human exposure to PFAS, specifically in relation to people who live or work in areas with contaminated drinking water sources associated with the production of PFAS. Public concerns and health effects of interest are a central focus of public health advice for PFAS, with vast resources available in lay and technical formats.

Nature of Exposure to PFAS in the US

The C8 Health Project conducted from 2005–2006 in the Mid-Ohio River region, US was a highly significant epidemiological study of human exposure to PFAS and the largest to date with more than 69,000 study participants (C8 Science Panel, 2012; Frisbee et al, 2009). Mean blood serum PFOA concentrations were 32.9 ng/mL for people who lived in the area affected by drinking water contamination from a PFOA manufacturing facility (Frisbee et al, 2009; Steenland et al, 2009).

Currently, the US ATSDR is investigating exposure to PFAS and the potential health effects in more than 30 communities impacted by local environmental contamination with PFAS, including a series of seven epidemiological studies included in the PFAS Multi-site Study established through the National Defense Authorization Acts of 2018–2019 (Agency for Toxic Substances and Disease Registry, 2019a). Recruitment for the PFAS Multi-site Study is in progress (Agency for Toxic Substances and Disease Registry, 2019a). Prior investigation in 2018 of the El Paso County, Colorado in the PFAS-AWARE Study, showed median blood serum concentrations for people who lived in an area impacted by AFFF-contaminated drinking water were 9.7 ng/mL for PFOS, 14.8 ng/mL for PFHxS, and 3.0 ng/mL for PFOA (Barton et al, 2020).

Blood serum concentrations of PFAS in the general population for the US are measured through the CDC as part of the National Health and Nutrition Examination Survey (NHANES). In 2017–2018, mean blood serum concentrations in the general population were 1.42 µg/L for PFOA and 4.25 µg/L for PFOS, showing a decline of more 70% for PFOA and 85% for PFOS since measurements commenced in 1999–2000 (Agency for Toxic Substances and Disease Registry, 2022a).

Public Health Advice regarding PFAS from the US CDC

Advice on the human health risks associated with human exposure to PFAS, including recommendations of testing for PFAS and other health screening measures, are under the provision of ATSDR of the US CDC. Across the US, public health advice references the information available from the ATSDR. However, in some cases, additional information specific to the findings of research conducted in the jurisdiction or other exposure control measures are available. Local health authorities across the US States may also synthesise available epidemiological and toxicological evidence. Conclusions of health advice at a sub-national level for the US was beyond the scope of this rapid review.

In 2018, the ATSDR released the draft Toxicological Profile for Perfluoroalkyls for public consultation, which reviewed and synthesised all peer-reviewed toxicological and

epidemiological for human exposure to 10 PFAS (including PFOS, PFHxS and PFOA) published until September 2018 (Agency for Toxic Substances and Disease Registry, 2021b). Following peer-review an independent, non-governmental panel and synthesis of additional evidence, the ATSDR published the Toxicological Profile for Perfluoroalkyls in May 2021, which included updates until March 2020 (Agency for Toxic Substances and Disease Registry, 2021b). The final report prepared by the ATSDR is the current basis of public health advice for PFAS in the US and incorporated into lay and technical resources published by the US CDC (Agency for Toxic Substances and Disease Registry, 2021b).

The ATSDR reports the following adverse health effects potentially associated with human exposure to PFAS, with reference to the ATSDR Toxicological Profile for Perfluoroalkyls report and the National Toxicology Program Monograph on Immunity Associated with Exposure to PFOA and PFOS (Agency for Toxic Substances and Disease Registry, 2021b; 2022a; National Toxicology Program, 2016):

- Increases in cholesterol levels (PFOA, PFOS, PFNA and perfluorodecanoic acid (PFDA).
- Changes in liver enzymes (PFOA, PFOS and PFHxS).
- Change in indicators of immune response (following vaccination) (PFOA, PFOS, PFHxS and PFDA).
- Increases in kidney and testicular cancer.
- Increases in pregnancy induced hypertension or pre-eclampsia in pregnant women (PFOA and PFOS).
- (Small) decreases in birth weight in babies (PFOA and PFOS).

Although the ATSDR synthesised toxicological evidence for PFAS, the public health guidance repeatedly refers to the limitations of current evidence to inform potential human health risks, providing the following conclusions (Agency for Toxic Substances and Disease Registry, 2021b):

> *"The mechanisms of toxicity of perfluoroalkyls have not been fully elucidated… although physiologically based pharmacokinetic (PBPK) models have been developed for rodents and humans, these models are not sufficient to allow for direct comparisons between administered doses in laboratory animals and serum concentrations in humans."*

Prior to the systematic review by the ATSDR, the National Toxicology Program Monograph on Immunity Associated with Exposure to PFOA and PFOS provided information on the potential immunotoxicity associated with human exposure to PFAS, based on data from animal models, mechanistic studies, and epidemiological studies (National Toxicology Program, 2016). A

summary of the Monograph on Immunity Associated with Exposure to PFOA and PFOS is available in Appendix A (annotated reference XIX). The Monograph included the following statements:

> *"PFOA is presumed to be an immune hazard to humans based on a high level of evidence that PFOA suppressed the antibody response from animal studies and a moderate level of evidence from studies in humans."*
>
> *"PFOS is presumed to be an immune hazard to humans based on a high level of evidence that PFOS suppressed the antibody response from animal studies and a moderate level of evidence from studies in humans."*

Based on the association of human exposure to PFAS and decreases in immune response following vaccination, the ATSDR refers to potential public concern related to SARS-CoV-2 infection and COVID-19 illness, with further reference to the Monograph on Immunity Associated with Exposure to PFOA and PFOS (Agency for Toxic Substances and Disease Registry, 2022a; National Toxicology Program, 2016). However, the ATSDR does not draw conclusions on potential risks related to COVID-19 illness, citing the need for further research.

Broader public heath advice is available across lay and technical resources published by the ATSDR (Agency for Toxic Substances and Disease Registry, 2022a). Notably, two resources present key information on ATSDR recommendations for blood testing for PFAS and general health screening — the Talking to Your Doctor about Exposure to PFAS webpage for individuals and the PFAS Clinician Factsheet (Agency for Toxic Substances and Disease Registry, 2019b; 2022b)

The Talking to Your Doctor about Exposure to PFAS webpage presents clear and concise information on questions individuals could ask their doctor if they are concerned about their exposure to PFAS. Overall, the ATSDR public health advice is general in nature and does not respond to individuals' potential health risks associated with PFAS, which may be related to age, sex, health status or other characteristics. A summary of the Talking to Your Doctor about Exposure to PFAS webpage content is available in Appendix A (annotated reference XVII). The advice provides information on health screening and draws the following conclusions:

> *"We don't know if exposure to PFAS may cause health problems in the future. You can talk to your doctor if you have been exposed to PFAS and ask if you need to be monitored for symptoms or conditions that may be caused by PFAS exposure … Some of the health effects possibly linked to PFAS exposure, like*

high cholesterol, can be checked as part of your annual physical. It is important to have regular check-ups and screenings."

Although the ATSDR recommends health screening for potential health effects associated with exposure to PFAS, the public health advice acknowledges that measurements of blood serum PFAS concentrations in an individuals' blood does not relate to their current or future health status, with no clinical intervention or management criteria currently available for PFAS (Agency for Toxic Substances and Disease Registry, 2022b). In addition to general health guidance for children and adults, the Talking to Your Doctor about Exposure to PFAS webpage provides information specific to pregnant women, noting the associations of exposure to PFAS with pregnancy induced hypertension and pre-eclampsia:

"Checking for high blood pressure should be part of your routine prenatal care. It is important to go to all of your prenatal checkups and discuss with the doctor or nurse any health concerns."

The ATSDR recommends that women continue breastfeeding their infant, due to the benefits of breastfeeding for both maternal and infant health (Agency for Toxic Substances and Disease Registry, 2021a; b; 2022a; b). Further information on PFAS and breastfeeding is available in a separate factsheet (Agency for Toxic Substances and Disease Registry, 2021a).

The ATSDR PFAS Clinician Factsheet provides a detailed overview of scientific and public health advice for PFAS specific to medical professionals (Agency for Toxic Substances and Disease Registry, 2019b). A summary of the ATSDR PFAS Clinician Factsheet is available in Appendix A (annotated reference XVIII). Notably, descriptions of the health effects associated with human exposure to PFAS do not use the same terminology to describe the level of evidence available to support the conclusions as the public health advice provided by the ATSDR (Agency for Toxic Substances and Disease Registry, 2022a; b). The Clinician Factsheet reports the following conclusions on the potential human health effects associated with PFAS:

- Inconsistent associations for cholesterol levels, with no causal relationship established.
- Potential reverse causality for associations for uric acid levels, with no causal relationship established.
- Inconsistent associations for liver enzyme levels, with no causal relationship established.
- Change in measures of kidney function, with differences by age, sex, ethnicity and health status, and no causal relationship established.

- Inconsistent associations for measures of body fat and obesity, and other cardio-metabolic health risks, with no causal relationship established.
- Inconsistent associations for thyroid hormone levels, with no causal relationship established.
- Decreases in indicators of immune response (following vaccination).
- Inconsistent associations for ulcerative colitis, with no causal relationship established.
- Inconsistent associations for asthma in children, with no causal relationship established.
- Inconsistent associations for neurobehavioural outcomes in children, with no causal relationship established.
- Inconsistent associations for indicators of female and male fertility, with no causal relationship established.
- Inconsistent associations for pregnancy induced hypertension and pre-eclampsia in pregnant women, with no causal relationship established.
- Decreases in birth weight for babies, with inconsistent results for statistical significance and no causal relationship established.
- Inconsistent associations for prostate, kidney, and testicular cancers, with no causal relationship established.

The Factsheet also provides specific information on the advice to provide to patients if they ask the following questions related to their exposure to PFAS:

- *"There are high levels of PFAS in my water. What should I do?"*
- *"Could my health problems be caused by PFAS exposure?"*
- *"Will I have future health problems because of PFAS exposure?"*
- *"Should I get a blood test for PFAS?"*
- *"What do my PFAS blood test results mean?"*
- For an adult patient — *"Should I be tested for any of the potential health effects associated with PFAS exposure?"*
- For a parent of a child patient — *"Should I have my child tested for any of the potential health effects associated with PFAS exposure?"*
- *"How will exposure to PFAS affect my pregnancy?"*
- *"Is it safe for me to breastfeed my baby?"*
- For a parent of a child patient — *"How will exposure to PFAS affect my child's immunisations? Will my child need to be vaccinated again?"*
- *"I have been very worried about health risks from PFAS exposure. How can I deal with this uncertainty?"*

For questions that reference individual blood testing for PFAS, the Factsheet reports the limitations in relation to clinical intervention and management for human health, with the following conclusion:

> *"There are no health-based screening levels for specific PFAS that clinicians can compare to concentrations measured in blood samples. As a result, interpretation of measured PFAS concentrations in individuals is limited in its use."*

Across several resources, the ATSDR references the PFAS Multi-site Study and other blood testing for PFAS conducted in areas impacted by environmental contamination (Agency for Toxic Substances and Disease Registry, 2019a). To provide an alternative and accessible measure of potential exposure to PFAS for impacted communities, the ATSDR developed an online tool (based on pharmacokinetic modelling) for individuals to estimate their blood serum concentrations of PFOA, PFOS, PFHxS and PFNA based on the concentrations of PFAS in their drinking water supply (with consideration of water treatment systems for PFAS) and general background information, such as age and sex (Agency for Toxic Substances and Disease Registry, 2023). Notably, the ATSDR does not intend for the online tool to replace individual blood testing for PFAS. The online tool was released in 2023 and is available at https://www.atsdr.cdc.gov/pfas/resources/estimating-pfas-blood.html.

The USEPA refers to the ATSDR resources for the latest available information on the health effects of human exposure to PFAS (United States Environmental Protection Agency, 2023). However, the USEPA list additional health effects as potentially associated with PFAS based on peer-reviewed evidence, with the following conclusions:

- Increases in cholesterol levels.
- Decreases in indicators of immune response (following vaccination).
- Increases in kidney, testicular and prostate cancer.
- Increases in high blood pressure in pregnant women.
- Decreases in birth weight in babies.
- Increases in developmental delays in children, such as behavioural and skeletal changes.
- Decreases in (i.e., acceleration of) the onset of puberty.
- Decreases in fertility.
- Changes in hormone levels.
- Increases in risk of obesity.

In addition, the USEPA advise mothers to consult a clinician on breastfeeding their infant, although reference the benefits of breastfeeding for mother and infant health. A summary of the USEPA advice is available in Appendix A (annotated reference XX).

Information on the potential health effects associated with PFAS from the American Cancer Society reports associations for kidney and testicular cancers for PFOA observed in occupational cohorts and communities impacted by environmental contamination of PFAS in the US (American Cancer Society, 2023). The American Cancer Society further recognises thyroid cancer as a potential health effect of PFAS, however notes the potential role of chance in epidemiological studies. A summary of the American Cancer Society webpage is available in Appendix A (annotated reference XXI).

The American Cancer Society provides additional information on individual blood testing for PFAS, including advice to speak to a clinician for concerns associated with exposure to PFAS, specifically for people who live or work in communities impacted by environmental contamination. The American Cancer Society acknowledges that blood testing for PFAS is not a standard pathology test conducted in the US and cannot provide information on an individuals' immediate or future health risks.

3.3 Comparison of National and International Public Health Advice for PFAS with Emerging Epidemiological Evidence

Public health advice for PFAS in Australia, the EU, and the US is largely consistent in the way that the potential health effects associated with human exposure to PFAS are reported. However, there are several important differences across key documents from health and environmental agencies. We compare the national and international public health advice with reference to key epidemiological evidence for PFAS. Based on our scientific database search, we identified 99 reviews, including systematic reviews, meta-analyses, and scoping reviews, published in the past five years that reported on the evidence of human health effects associated with PFAS. Although there are many scientific publications, notably systematic reviews, that have reported associations with PFAS over recent years, many of them represent a re-evaluation of previous key or pivotal studies. Where there are multiple systematic reviews for a health outcome, they usually include the same studies and reach similar conclusions. Consequently, they do not necessarily represent significant advances in the scientific evidence base around PFAS and health effects. In this rapid review, we discuss evidence from reviews related to adverse health outcomes referred to in public health advice.

3.3.1 Cancer outcomes

Across national and international public health advice for PFAS, cancer outcomes are highlighted as a key concern of exposure to PFAS among communities impacted by environmental contamination, as well as occupational cohorts. In Australia, the enHealth Guidance Statements do not report cancer as a potential adverse health effect associated with human exposure to PFAS (Environmental Health Standing Committee (enHealth), 2019). The Expert Health Panel for PFAS report concluded there was *"no current evidence that suggests an increase in overall cancer risk"* (Buckley et al, 2018). However, the Expert Health Panel refers to the limited epidemiological evidence of kidney and testicular cancers related to PFOA, and the toxicological evidence related to tumour induction in rodents for PFOA and PFOS, with the caveat of reviewing a small number of epidemiological studies that had a lack of consistent findings and potential for bias, particularly associated with the role of confounding (Buckley et al, 2018). Both the US ATSDR Toxicological Profile for Perfluoroalkyls report and the EEA health advice conclude evidence of increases in the risk of kidney and testicular cancer associated with increases in human exposure to PFAS, with specific reference to epidemiological associations observed in highly exposed populations (Agency for Toxic Substances and Disease Registry, 2021b; 2022a; European Environmental Agency, 2019).

Key documentation for public health advice across Australia, the EU and the US references the 2016 IARC Monograph on PFOA, which categorised PFOA as a Group 2B Carcinogen i.e., possibly carcinogenic to humans, based on limited evidence available for kidney and testicular cancer from epidemiological data on occupational cohorts, community populations impacted by environmental contamination of PFAS, and the general population (International Agency for Research on Cancer, 2016). In November 2023, the IARC working group classified PFOA as carcinogenic to humans, based on sufficient animal cancer evidence and strong mechanistic evidence for humans (International Agency for Research on Cancer, 2023). PFOS was classified as possibly carcinogenic based on strong mechanistic evidence (International Agency for Research on Cancer, 2023). Due to the recency of this classification, the IARC conclusions are not currently included in public health advice for human exposure to PFAS across Australia, the EU and the US. It is important to note that the IARC does not consider dose or exposure measures in their findings on carcinogenicity, and therefore, does not advise any indications of the health risks posed to communities impacted by environmental contamination or occupational cohorts (International Agency for Research on Cancer, 2023).

In relation to further emerging evidence for cancer outcomes, we identified three recent systematic reviews on PFAS and cancer that support kidney and testicular cancer as potential

health outcomes associated with PFAS exposure (Bartell & Vieira, 2021; Seyyedsalehi & Boffetta, 2023; Steenland & Winquist, 2021). The first focused on PFOA, finding a dose response association between PFOA and kidney and testicular cancer, noting that only a small number of studies were included in the meta-analysis for testicular cancer (Bartell & Vieira, 2021). The second, a systematic review and meta-analysis of 15 cohort and case-control studies, found associations between high levels of PFAS exposure and kidney cancer and testicular cancer, and all PFAS exposures and kidney cancer (Seyyedsalehi & Boffetta, 2023). The third reviewed 28 epidemiological studies that reported a quantitative assessment of the association of human exposure to PFAS and cancer outcomes, identifying that *"the cancer sites with the most evidence of an association with PFAS are testicular and kidney cancer"* with further inconsistent evidence available for prostate cancer (Steenland & Winquist, 2021). However, Steenland and Winquist (2021) concluded that the evidence of the conclusions for cancer outcomes is from a limited number of epidemiological studies which have important limitations in relation to study design and the potential for confounding (Steenland & Winquist, 2021). Calvert et al. (2021) conducted a (narrative) review, noting that while testicular cancer is widely considered a human health endpoint of PFAS, several studies of occupational exposure did not find associations with mortality from testicular cancer, which was also highlighted in relation to kidney cancer by Steenland and Winquist (2021) (Calvert et al, 2021; Steenland & Winquist, 2021). We did not identify any further new, high-quality synthesised evidence for an association between human exposure to PFAS and other cancers.

3.3.2 Immunological Outcomes

Public health advice for PFAS across Australia, the EU and the US all reference potential adverse immunological outcomes associated with human exposure to PFAS, specifically lower antibody responses following vaccination. From Australia, the Expert Health Panel for PFAS reported that PFAS *"are likely to alter the function of the immune system"*, however highlight the uncertainty related to the clinical significance of changes to the immune response (Buckley et al, 2018). The EEA refers to these immunological outcomes as immunotoxicity (European Environmental Agency, 2019). The US National Toxicology Program Monograph on Immunity Associated with Exposure to PFOA and PFOS further recognises PFOA and PFOS as immune hazards, primarily based on data from animal models (National Toxicology Program, 2016). The ATSDR Toxicological Profile for Perfluoroalkyls also reports immune toxicity observations in animal models and refer to the evidence for immunotoxicity for PFOA, PFOS, PFHxS and PFDA from epidemiological studies of antibody responses following vaccination (Agency for Toxic Substances and Disease Registry, 2021b).

As a basis for conclusions of the carcinogenicity of PFOA and PFOS, the IARC reported strong mechanistic evidence for immunosuppression (International Agency for Research on Cancer, 2023). Conclusions for immunological responses associated with human exposure to PFAS are based on antibody responses to vaccinations in children, with specific reference to evidence from a cohort of children from the Faroe Islands (Grandjean et al, 2012). Pre- and postnatal exposure measurements of PFAS and antibody concentrations following standard childhood vaccination regimes were assessed in the Faroe Islands cohort across several epidemiological studies, identifying associations with lowered serum tetanus and diphtheria antibodies (Ehrlich et al, 2023; Grandjean et al, 2012). In 2023, researchers involved in the Faroe Islands investigations released a review on the potential mechanistic pathways associated with human exposure to PFAS and adverse immunological outcomes, concluding that *"there is substantial evidence from both in vitro and in vivo experimental as well as epidemiological studies, supporting that various PFAS, not only PFOA and PFOS, affect multiple aspects of the immune system"* (Ehrlich et al, 2023). The comprehensive assessment of 487 publications on PFAS and immune function, including *in vivo*, *in vitro*, and epidemiological studies, found associations of increases in blood serum PFAS concentrations and decreases in vaccine antibody levels, with the strongest associations in children (Ehrlich et al, 2023). The review highlighted the role that exposure timing can play in determining the association (Ehrlich et al, 2023). In contrast, a previous review by Antoniou et al. (2022) of toxicological and epidemiological evidence reported that *"based on an analysis of the available human epidemiology, the overall level of evidence regarding associations between PFAS serum levels and reduced antibody response remains weak"*, with limited evidence available to support immunomodulation association with PFAS (Antoniou et al, 2022).

We identified three additional systematic reviews that report associations of PFAS and decreases in immune function that supports public health advice across Australia, the EU and the US (Crawford et al, 2023; von Holst et al, 2021; Zhang et al, 2022). Two systematic reviews of studies in children found reduced antibody response to vaccination in children with higher levels of PFOA, PFOS and PFHxS exposure (von Holst et al, 2021; Zhang et al, 2022). A third systematic review of 14 studies of vaccine response in all ages also found moderate support for associations between PFOA, PFOS or PFHxS and some vaccine responses in children (Crawford et al, 2023). Findings varied across these reviews by vaccine. For example, data were more consistent for tetanus than other vaccines.

There are limited data available for antibody responses to vaccinations for adults. Although not yet synthesised in a systematic review, antibody responses after a two-dose SARS-CoV-2 vaccination were investigated in the Ronneby Biomarker Cohort, Sweden from 2021–2022

(Andersson et al, 2023). A related research article published in August 2023 reported no association of decreases in antibody response following SARS-CoV-2 vaccination at five weeks and six months intervals for various measures of human exposure to PFAS, including prenatal exposure, address-based modelling, and blood serum concentrations of PFAS from the original measurement in 2014–2016 and current study period (Andersson et al, 2023).

3.3.3 Biochemical Marker Outcomes

Across Australia, the EU and the US, public health advice for PFAS refers to changes in levels of biochemical markers measured in blood, including standard pathology tests used to assess health outcomes. Key documentation from Australia, the EU and the US refers to increases in cholesterol levels associated with human exposure to PFAS (Agency for Toxic Substances and Disease Registry, 2021b; 2022a; Buckley et al, 2018; Environmental Health Standing Committee (enHealth), 2019; European Environmental Agency, 2019). KEMI refers to increases in cholesterol levels specific to exposure to PFOA and the ATSDR references increases in cholesterol levels associated with exposure to PFOA, PFOS, PFNA and PFDA (Agency for Toxic Substances and Disease Registry, 2021b; Swedish Chemicals Agency (Kemi), 2023). We identified two systematic reviews which both support public health advice for increases in cholesterol levels associated with human exposure to PFAS (Ho et al, 2022; Liu et al, 2023). An earlier review highlighted limitations of epidemiological evidence for increases in cholesterol levels due to the reliance on cross-sectional data, concluding that the relevance of the findings for human health was unclear and that further evidence from mechanistic studies was required (Fragki et al, 2021).

Public health advice for other biochemical marker outcomes associated with PFAS is inconsistent across Australia, the EU and the US. In Australia, the enHealth Guidance Statements report indications of decreases in kidney function, including increases in uric acid concentrations, associated with exposure to PFAS (Environmental Health Standing Committee (enHealth), 2019). The Expert Health Panel for PFAS report concludes a *"clear link to kidney function with consistently shown associations between PFAS and uric acid/kidney function in key reports and reviews"*, however refers to the potential role of reverse causality in relation to the elimination of PFAS from the human body (Buckley et al, 2018). Key documentation from the EU and US do not refer to kidney outcomes, except for kidney cancer. Emerging synthesised evidence on kidney function is limited to one scoping review, which included 21 epidemiological studies, supported reduced kidney function (Stanifer et al, 2018).

Both the EEA and ATSDR specify the potential association of exposure to PFAS and liver damage, with the ATSDR specifying changes in concentrations of liver enzymes associated with exposure

to PFOA, PFOS and PFHxS (Agency for Toxic Substances and Disease Registry, 2021b; 2022a; European Environmental Agency, 2019). The systematic review and meta-analysis for biochemical markers of liver function of 24 studies supports an association between PFOA and altered liver function, and PFNA and altered liver function (Costello et al, 2022).

The EEA and Danish EPA also reference changes to concentrations of thyroid hormones (Danish Ministry of the Environment, 2015; European Environmental Agency, 2019). The enHealth Guidance Statements report changes in thyroid and sex hormones, however the Expert Health Panel for PFAS report concludes *"no consistent associations between any particular PFAS and thyroid hormones"* (Buckley et al, 2018). The ATSDR does not include thyroid outcomes in public health advice, however the USEPA refers to changes in concentrations of sex hormones associated with PFAS exposure (Agency for Toxic Substances and Disease Registry, 2021b; 2022a; United States Environmental Protection Agency, 2023). Three recent systematic reviews on thyroid hormones indicate that maternal PFAS concentrations may affect thyroid hormones in neonates, but findings for the effect of different types of PFAS associated with thyroid hormone concentrations were inconsistent (Boesen et al, 2020; Sun et al, 2022; Zhang et al, 2023). A meta-analysis of 11 studies described alterations in sex hormones across PFAS exposure, with stronger associations in children than adults (Li et al, 2024). However, a systematic review of 11 studies of exposure to PFAS and sex hormones levels in children found no consistent association (Lee et al, 2021). Another review of male reproductive health found some evidence for single associations but no consistent associations across the current evidence base for PFAS (Petersen et al, 2020).

3.3.4 Maternal and Child Outcomes

Public health advice for PFAS across Australia, the EU and the US consistently refers to potential associations of lower birth weight and human exposure to PFAS, on the basis of epidemiological investigations of measurements of maternal and neonatal blood measurements of PFAS. In Australia, the Expert Health Panel for PFAS reports evidence of lower birth weight associations identified in epidemiological studies of exposure to PFAS in the general population, rather than highly exposed populations (Buckley et al, 2018). The Expert Health Panel concluded that decreases in birth weight associated with exposure to PFAS *"were mostly small and within the normal range"* (Buckley et al, 2018). The ATSDR provides the same conclusion in relation to small decreases in birth weight specific to human exposure to PFOA and PFOS (Agency for Toxic Substances and Disease Registry, 2021b; 2022a). We identified five systematic reviews of the association of birth weight and exposure to PFAS (Gui et al, 2022; Lan et al, 2023; Lee et al, 2021; Steenland et al, 2018; Wright et al, 2023). Small decreases in birth weights associated with higher PFAS exposure were reported in two recent meta-analyses by

Gui et al. (2022) and Lan et al. (2023), and three further systematic reviews by Steenland et al. 2018, Lee et al. (2021) for PFOA, and Wright et al. (2023) for PFNA). While the epidemiological evidence is consistent with public health advice, uncertainty remains as to the relevance for adverse health outcomes, including the clinical significance of small decreases in birth weight.

The ATSDR specify associations of pregnancy induced hypertension and pre-eclampsia and exposure to PFAS in pregnant women, with reference to PFOA and PFOS (Agency for Toxic Substances and Disease Registry, 2021b; 2022a). The ATSDR also notes potential concerns that pregnant women may have in relation to these health outcomes, advising to ask a clinician about their exposure to PFAS and that *"checking for high blood pressure should be part of [their] routine prenatal care"* (Agency for Toxic Substances and Disease Registry, 2022b). In Australia, public health advice for PFAS does not refer to pregnancy induced hypertension and pre-eclampsia (Environmental Health Standing Committee (enHealth), 2019). The Expert Health Panel for PFAS concluded that *"evidence does not support PFAS being a major cause of pregnancy-induced hypertension/pre-eclampsia or other complications"* (Buckley et al, 2018*)*. The EEA also referred to the lower level of evidence associated with increases in pregnancy induced hypertension and pre-eclampsia in pregnant women (European Environmental Agency, 2019). A recent meta-analysis of 15 studies found associations between PFOA, PFOS, PFHxS and pre-eclampsia (all at low certainty, except PFOS with moderate certainty), and a low certainty association between PFOS and hypertension (Hu et al, 2023). Further systematic review evidence on maternal and neonatal outcomes is limited. Several narrative reviews, however, have described positive associations seen across epidemiological studies of maternal PFAS exposure and pre-eclampsia (Blake & Fenton 2020), and hypertensive disorders more broadly (including pre-eclampsia and gestational hypertension) (Blake & Fenton, 2020; Chambers et al, 2021; Erinc et al, 2021).

Key documentation for public health advice for PFAS across Australia, the EU and the US does not refer to potential neurodevelopmental effects, with the exception of the USEPA which references increases in developmental delays in children, such as behavioural and skeletal changes (United States Environmental Protection Agency, 2023). Other emerging health evidence investigated PFAS exposure and neurodevelopmental outcomes. Gao et al. (2023) qualitatively synthesised 31 birth cohort studies and found that prenatal PFAS exposure was associated with poor neurodevelopment (by cognition and neurobehavior) in children (Gao et al, 2023). Shin et al. (2022) reviewed seven studies of PFAS and autism-spectrum disorder, finding three of seven demonstrated an increased risk (Shin et al, 2022). Starnes et al. (2022), however, conducted a critical review and meta-analysis of human epidemiological, experimental, and

wildlife data on neurodevelopment and highlighted the limited available and inconsistent evidence for the impacts of PFAS on human neurodevelopment (Starnes et al, 2022).

3.3.5 Other Outcomes

Public health advice for PFAS across Australia, the EU and the US inconsistently refers to other adverse health outcomes potentially associated with human exposure to PFAS, such as indicators of onset of puberty, menopause and fertility.

A potential association for exposure to PFAS and later age for starting menstruation (periods) in girls is referred to by the enHealth Guidance Statements in Australia (Environmental Health Standing Committee (enHealth), 2019). Recent systematic reviews have noted inconsistencies in the evidence base, with several studies finding no associations and others find some association with delayed menarche (Lee et al, 2021; Schell & West, 2023). Notably, the EEA and USEPA presents public health advice that contrasts the enHealth Guidance Statements, referring to decreases of (i.e., acceleration of) the age of onset of puberty, however, the EEA refers to a lower level of certainty available based on current evidence (European Environmental Agency, 2019; United States Environmental Protection Agency, 2023).

The enHealth Guidance Statements in Australia also refer to earlier menopause in women association with exposure to PFAS (Environmental Health Standing Committee (enHealth), 2019). There is limited emerging evidence on the subject. However, two narrative reviews described previous evidence for positive associations between PFAS levels and early menopause (Levine & Hall, 2023; Neff et al, 2022).

Across Australia, the EU and the US, key documentation of public health advice does not included conclusions on decreases in fertility for males or females, however the EEA references that limited evidence is available for potential decreases in indicators of male fertility, including sperm count and mobility, and increases in the time period to pregnancy (European Environmental Agency, 2019). The USEPA also refers to decreases in fertility, in contrast to the ATSDR conclusions (Agency for Toxic Substances and Disease Registry, 2021b; United States Environmental Protection Agency, 2023).

Public health advice does not reference evidence of other adverse health outcomes associated with human exposure to PFAS. Recent systematic reviews have highlighted potential associations between PFAS and other health outcomes: cardiovascular disease (Soheimi et al, 2021); hypertension (Pan et al, 2023; Xiao et al, 2023; Yang et al, 2023); other birth outcomes (Deji et al, 2021; Gao et al, 2021; Gui et al, 2023); reproductive outcomes (Wang et al, 2023);

(Wang et al. 2023); allergies (Luo et al, 2020; von Holst et al, 2021); diabetes (Gui et al, 2023); and childhood obesity (Frigerio et al, 2023; Liu et al, 2018).

4 Human Health-Based Guidance Values for PFAS

A HBGV is a science-based recommendation for the maximum (oral) exposure to a substance that is not expected to result in an appreciable health risk, taking into account current safety data, uncertainties in these data, and the likely duration of consumption. National and international agencies have established Human HBGV for a range of substances that may occur in food and/or water such as pesticides, contaminants and toxins. A HBGV can then be used to recommend standards and other risk management measures to decrease exposure to the substance and to protect public health. In this section, we outline and compare the HBGV for PFAS in Australia, the EU, and the US, including the methodology used to derive them, the key numbers such as the TDI (or equivalents) and critical health endpoints used in each region.

4.1 Summary of National and International HBGV for PFAS

A summary of HBGV in Australia, the EU, and the US with a description of the associated PFAS, HBGV type and the adverse health effect for the basis of the critical endpoint is shown in Table 2.

Table 2. Summary table for HBGV for PFAS in Australia, the EU, and the US.

Agency	Chemical	Type of HBGV	Value of HBGV	Adverse Effect Chosen to Establish Endpoint	Species
Australia					
FSANZ	PFOS and PFHxS combined	TDI	20 ng/kg bw/day	Reproductive toxicity	Rat
FSANZ	PFOA	TDI	160 ng/kg bw/day	Developmental and reproductive toxicity	Mouse
EU					
EFSA	PFOA, PFNA, PFHxS and PFOS combined	TWI	4.4 ng/kg bw/week	Decreased serum diphtheria antibody titres in children	Human
US					
USEPA	PFOS	RfD	0.0079 ng/kg bw/day	Decreased serum diphtheria antibody titres in children	Human
USEPA	PFOA	RfD	0.0015 ng/kg bw/day	Decreased serum tetanus antibody titres in children	Human

TDI: tolerable daily intake and is an estimate of the amount of a substance in air, food or drinking water that a person can be exposed to over a lifetime every day without appreciable health risk.

TWI: tolerable weekly intake and is an estimate of the amount of a substance in air, food or drinking water that a person can be exposed to over a lifetime throughout a week without appreciable health risk.

RfD: reference dose and is an estimate of the amount of a substance in air, food or drinking water that a person can be exposed to over a lifetime every day without appreciable health risk.

4.2 Derivation of National and International HBGV for PFAS

4.2.1 Australia

In 2017 after a comprehensive review of PFAS chemicals for the purposes of reviewing the HBGV for PFAS, FSANZ concluded that the available human epidemiological data were not suitable to support the derivation of a TDI for PFOS or PFOA (Food Standards Australian New Zealand, 2017).

The recommended TDIs were based on the findings of toxicological studies in laboratory animals. For PFOS, FSANZ recommended a TDI of 20 ng/kg bw/day based on decreased parental and offspring body weight gains in a multigeneration reproductive toxicity study in rats. The TDI was derived by applying pharmacokinetic modelling to the serum PFOS concentrations measured in experimental animals at the no-obvious-adverse-effect-levels (NOAELs) in these and other critical studies, to calculate human equivalent doses (HED). An uncertainty factor of 30 was applied to the HEDs, which comprised a default factor of 3 to account for interspecies differences in toxicodynamics and a default factor of 10 for intraspecies differences in the human population.

For PFOA, FSANZ has recommended a TDI of 160 ng/kg bw/day based on a NOAEL for foetal toxicity in a developmental and reproductive study in mice. Physiological based pharmacokinetic modelling (PBPK) was applied to the serum concentrations at the NOAEL and above to calculate the HED. An uncertainty factor of 30 was applied to the HED, which comprised a default factor of 3 to account for interspecies differences in toxicodynamics and a default factor of 10 for intraspecies differences in the human population.

For both PFOS and PFOA, given the marked variation in both their half-lives in the various species, a pharmacokinetic modelling approach (that recognises and adjusts for half-life and other pharmacokinetic variation in and between species) was preferred to an approach based on the use of the traditional NOAEL, together with the application of a default uncertainty factor to account for pharmacokinetic differences.

There was insufficient toxicological and epidemiological information to justify establishing a TDI for PFHxS. It was concluded that the approach of using the TDI for PFOS is likely to be conservative and protective of public health and as a result, PFHxS and PFOS were summed for the purposes of a dietary exposure assessment and risk characterisation.

Review of Immunomodulation Effects

FSANZ first reviewed the potential for PFAS to affect the human immune system when it established HBGV for PFOS and PFOA in 2017 (Food Standards Australian New Zealand, 2017). FSANZ considered that PFOS and PFOA were a potential immune hazard to humans, but the exposure levels required to produce immunomodulation were unknown. Adverse effects on the immune system in animals were only observed at very high doses, relative to those to which human populations are exposed. It was concluded that the available epidemiological information could not be used for risk assessment purposes.

In a subsequent comprehensive review in 2018, the Expert Health Panel for PFAS identified that there were few human studies on PFAS and immunological effects, a lack of consistency between studies, and a substantial risk of bias or chance (Buckley et al, 2018). The Expert Health Panel observed that the strongest evidence for a link between PFAS and clinically important immunological effects was for impaired vaccine response, but that the human dose-response threshold for potential immune effects was very poorly characterised, and the overall human evidence was weak (Buckley et al, 2018). It was concluded that while PFAS are likely to alter the function of the immune system, it was unclear if this occurs at current exposures or has any clinically important consequences (Buckley et al, 2018).

In 2021, FSANZ reviewed and evaluated new human epidemiological information around the relationship between PFAS blood levels and immunomodulatory effects that had not been previously considered (Food Standards Australian New Zealand, 2021). Available new studies looked at three different potential immunomodulatory effects of PFAS: decreased circulating antibody titres to vaccine-preventable diseases (VPDs); increased incidence of infectious diseases; and altered prevalence of hypersensitivity diseases such as asthma and allergies.

While some of the studies provided limited evidence of statistical associations, FSANZ concluded that a causal relationship between increased PFAS blood levels and impaired vaccine response or an increased sensitivity to infectious disease could not be established with certainty. Based on the uncertainties and limitations in the evidence base, FSANZ again concluded that immunomodulation was not a suitable critical endpoint for quantitative risk assessment for PFAS (Food Standards Australian New Zealand, 2021).

Trigger Levels and Exposure Assessment Guidance

A report published by FSANZ in 2017 assessed how much of an individual food or food group sourced from contaminated sites that contain PFOS, PFOA and/or PFHxS may be consumed by the Australian population without exceeding the relevant TDI (Food Standards Australian New Zealand, 2017). If a calculated amount for a specified chemical/food group(s) combination was less than people normally ate, then public advice on consuming these foods could be formulated when they were sourced from or near contaminated sites. In addition, trigger points for investigation were derived for each food or food group assessed for PFOS and PFHxS combined, and PFOA. Trigger points were the maximum concentration level of these chemicals that could be present in individual foods or food groups so even high consumers of these foods would not have dietary exposures exceeding the relevant TDI. Public health and/or food regulatory professionals have used these trigger points for investigation of specified chemicals to identify when levels in analysed foods exceed these values and require further public health advice around consumption of food within communities in contaminated sites.

4.2.2 European Union

The EFSA revised its scientific evaluation on the risks to human health related to the presence of PFAS in food in 2020 (EFSA Panel on Contaminants in the Food Chain et al, 2020). Based on several similar effects in animals, toxicokinetics and observed concentrations in human blood, an assessment was made for the sum of four PFAS chemicals: PFOA, PFNA, PFHxS and PFOS. These four PFAS contribute most to the levels observed in human serum. In humans, all four PFAS share toxicokinetic properties and show similar accumulation and long half-lives.

In its revised risk assessment, EFSA concluded that effects on the immune system, which were observed at the lowest serum PFAS levels in both animals and humans, were the most sensitive end points. The findings of a decreased immune response were consistently observed for the two studied PFAS (PFOA, PFOS) in rodents and in humans.

In 2018, the EFSA Panel used the effects of serum cholesterol levels to derive Tolerable Weekly Intakes (TWIs) for both PFOS and PFOA (EFSA Panel on Contaminants in the Food Chain et al, 2018). Those TWIs were also protective for the other potential critical endpoints. Although the association with increased cholesterol was observed in many studies, EFSA now considers uncertainty around this effect to be larger and does not see it as a causal relationship.

In relation to animal studies, some evidence shows that PFOS and PFOA can cause a reduced response to vaccination (T-cell-dependent antibody response) and PFOS also caused a reduced resistance to infection (EFSA Panel on Contaminants in the Food Chain et al, 2020). However, these are at high levels of exposure. Effects on the immune system were also seen for other PFAS, i.e. PFNA and PFDA, but the available database for these compounds was more limited and did not include vaccination response. The EFSA Panel concluded that the immune system is a prime target of PFAS (EFSA Panel on Contaminants in the Food Chain et al, 2020).

Two critical studies were considered for the derivation of the HGBV by EFSA. The first was a study in children on the Faroe Islands that showed various associations between the serum levels of individual PFAS, but also the sum of PFOA, PFNA, PFHxS and PFOS, and antibody titres against diphtheria and tetanus (EFSA Panel on Contaminants in the Food Chain et al, 2020; Grandjean et al, 2012). In addition, a study with children from Germany showed an inverse association between serum levels of PFOA, but also the sum of PFOA, PFNA, PFHxS and PFOS, and antibody titres against haemophilus influenzae type b (Hib), diphtheria and tetanus in serum sampled from one-year-old children, predominantly breastfed (Abraham et al, 2020; EFSA Panel on Contaminants in the Food Chain et al, 2020).

Outcomes from the second study above were chosen as the most sensitive end point based on the inverse association between serum levels of the sum of the four PFAS and antibody titres against diphtheria (Abraham et al, 2020).

From this study, a lowest BMDL10 (the lower 90% limit of the benchmark dose and used to approximate the lowest obvious adverse effect level or LOAEL) of 17.5 ng/mL was derived for the sum of PFOA, PFNA, PFHxS and PFOS at the age of one year. This BMDL10 was used to estimate the daily intake by mothers that would result in this critical serum concentration at 1 year of age in breastfed children. This daily intake was subsequently used to derive an HBGV for the sum of PFOA, PFNA, PFHxS and PFOS.

Using PBPK modelling, this serum level of 17.5 ng/mL in children was estimated to correspond to long-term maternal exposure of 0.63 ng/kg bw per day. Since accumulation over time is important, a TWI of 4.4 ng/kg bw per week was established. It was noted that this TWI would be protective for the other potential critical endpoints (increase in serum cholesterol, reduced birth weight and high serum levels of alanine transaminase (ALT)) considered in the previous EFSA opinion on PFOS and PFOA (EFSA Panel on Contaminants in the Food Chain et al, 2018).

4.2.3 United States

In June 2022, following a Science Advisory Board (SAB) expert peer-review, the USEPA identified immunotoxicity as the most sensitive adverse health effect of chronic exposure to both PFOS and PFOA (United States Environmental Protection Agency, 2022a; b). From this, reference doses (RfD) were derived for the purposes of establishing health advisory levels in drinking water. The RfD, like a TDI, developed by the USEPA is an estimate of a daily oral exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime.

For both PFOS and PFOA, the Faroe Island study was selected as a suitable study population as this population was identified as having an early childhood body burden of PFAS, and data were available for pre- and post-natal exposures to PFAS (Grandjean et al, 2012). An association between elevated PFOS or PFOA serum with decreased serum tetanus antibodies in seven-year-old Faroe Island children was reported. The authors noted significant associations between maternal PFOS serum concentration and decreased child diphtheria antibodies pre-booster and elevated child PFOS serum concentration with decreased tetanus antibodies post-booster shot.

For both PFOS and PFOA, the EPA identified the most sensitive effects (points of departure (PODs)) from human epidemiological studies (immune, developmental and serum lipid endpoints) and animal studies using benchmark dose modelling. The internal dose POD were converted to POD human equivalent doses (PODHED) using pharmacokinetic modelling. To calculate the candidate reference dose (RfD) values, EPA applied an uncertainty factor for human intra-species variation to the PODHED derived from the immune and developmental epidemiological studies. Though multiple PODHED were derived for multiple health systems, the decreased serum anti-tetanus antibody concentrations in children, decreased serum anti-diphtheria antibody concentrations in children, and decreased body weight in babies were selected for candidate lifetime RfD derivation. These endpoints were chosen as candidate RfDs because of the robust (i.e., high quality) epidemiological and animal toxicity data supporting these effects and the concordance between many of the human and animal health outcomes, and because these endpoints represented the most sensitive effects after PFOS exposure in the lower dose range.

The RfD selected for PFOA was 1.5 x 10-9 mg/kg bw/day, based on decreased diphtheria antibodies in serum of children. The RfD for PFOS was 7.9 x 10-9 mg/kg bw/day, based on decreased tetanus antibodies in serum of children.

4.3 Comparison of National and International HBGV for PFAS

In Australia, FSANZ developed HBGV for PFAS using data from animal studies for toxic endpoints (Food Standards Australian New Zealand, 2017). Pharmacokinetic modelling and safety factors were then applied to derive the amounts of PFAS considered safe to consume over a lifetime. This methodology is considered a sound approach in the absence of appropriate high-quality human studies. Other European countries and Canada have also utilised this approach and have HBGV similar in magnitude to Australia.

In contrast, both the USEPA and EFSA have used human epidemiological studies to establish endpoints on which to base their HBGV, specifically immune effects in humans (EFSA Panel on Contaminants in the Food Chain et al, 2020; United States Environmental Protection Agency, 2022a; b). This latter approach resulted in significantly lower values for PFAS HBGV compared to those established in Australia and elsewhere. Lower HBGV are not necessarily more protective of public health if endpoints on which they are established come from studies with limitations and adverse effects have questionable clinically significance. The use of observational human epidemiological studies presents several limitations including difficulties in clearly defining an exposure, the possibility of confounding, and an inability to demonstrate causality. In its report on PFAS HBGV in 2017, and its subsequent review of the evidence around PFAS and immunotoxicity in 2021, FSANZ considered that it was inappropriate to base PFAS HBGV on the available human epidemiological studies that looked at immune effects as they had many limitations, and a clear causal effect was not apparent (Food Standards Australian New Zealand, 2017; 2021).

In establishing their HBGV, both the USEPA and EFSA chose a decreased antibody response to vaccines in humans as the most sensitive endpoint (EFSA Panel on Contaminants in the Food Chain et al, 2020; United States Environmental Protection Agency, 2022a; b). Antibody concentrations in children may occur with elevated blood levels of other contaminants such as polychlorinated biphenyls (PCBs) and mercury. Such chemicals may therefore be a confounding variable to the alleged association between PFAS levels and vaccine antibodies. Moreover, it remains unanswered whether the reduced antibody response used is clinically sufficient to cause increased infections or immune system dysfunction in humans. No mode of action by PFAS has been established for the proposed immunotoxicity effects. Some of these limitations have been highlighted by Perez et al. (2023) who additionally questioned the benchmark dose modelling employed by the USEPA and whether the critical lower endpoints chosen from this modelling were too low to represent toxic effects (Perez et al, 2023).

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6 Appendix A

6.1 Annotated Bibliography of Grey Literature Sources for Rapid Review

I. EnHealth. enHealth guidance statements on PFAS. Australian Government DoHAC Resources. 2019 Jun 1. URL: https://www.health.gov.au/resources/publications/enhealth-guidance-statement-on-per-and-polyfluoroalkyl-substances?language=en

A guideline document with information on PFAS to assist local state and territory health departments, including Public Health Units, on the human health risks associated with exposure to local environmental contamination of PFAS, with specific reference to PFOA, PFOS and PFHxS. Inclusion of seven guidance statements on PFAS related to human health:

- Report of the potential human health effects from exposure to PFAS.
- Recommendation to minimise potential exposure to PFAS where possible.
- Report of ingestion of contaminated food and water as the exposure pathways in areas impacted by environmental contamination.
- Recommendation for mothers to continue breastfeeding infants in areas impacted by environmental contamination.
- Recommendation for pregnant women to minimise potential exposure to PFAS where possible.
- Reference to the HBGV for PFAS in Australia.
- Report of the limitations of blood testing for PFAS, including the inability of blood testing to inform clinical management of potential adverse health effects associated with PFAS.

II. Buckley N, Sim M, Douglas K, Hakansson H. Expert Health Panel for PFAS: final report. Analysis and Policy Observatory. 2018 May 7. URL: https://apo.org.au/node/171461

Also published as: Australian Government DoHAC. Expert Health Panel's independent advice for PFAS. Australian Government DoHAC Media Releases. 2018 May 7. URL: https://www.health.gov.au/news/expert-health-panels-independent-pfas-advice

A report produced by the Expert Health Panel for the Australian Government that provides advice on the evidence for potential health impacts associated with PFAS exposure. The advice in the report is based on a comprehensive review of systematic reviews of human epidemiological studies and inter(national) authority/intergovernmental/governmental reviews published up to February 2018. For 14 health topics, the Expert Health Panel summarised recent findings,

provided advice to the minister on concerns and action priorities, and highlighted research priorities. The report also provides the results of a consultation with 109 members of the public on their concerns regarding PFAS exposure.

- Outlined the available evidence for cancer, metabolic biomarkers, liver function, kidney function, thyroid effects, neonatal/infant/maternal outcomes, reproductive outcomes, immunological effects, neurodevelopmental/physiological effects, diabetes, glycaemic control and metabolic syndromes, obesity/overweight/BMI, cardiovascular effects, respiratory effects, and skeletal effects.
- Acknowledgement that there is some research that identifies associations with health outcomes such as high cholesterol. However, there is limited or no evidence of human disease accompanying these associations and many of them are not considered to be clinically significant and require further research.
- Cancer risks for children and firefighters, and neonatal/infant/maternal and reproductive outcomes were key health concerns highlighted by consulted members of the public, comprised mainly of people from highly exposed communities. Future research into human health effects of PFAS exposure is extremely important to the public.
- Research in Australia should prioritise longitudinal studies, whole of population studies with linked data, understanding mechanisms of PFAS kinetics in humans, mechanisms for toxicity and diseases, and involvement of exposed occupational groups and communities.

III. Food Standards Australia and New Zealand and the National Medical Research Council. Health based guidance values for PFAS for use in site investigations in Australia. 2017 April 30. URL: https://www.health.gov.au/sites/default/files/documents/2022/07/health-based-guidance-values-for-pfas-for-use-in-site-investigations-in-australia_0.pdf

A guideline document with health-based guidance values to protect the Australian community from PFAS exposure in food, drinking water and recreational water. Recommendations from FSANZ include a TDI for PFOA, PFOS and PFHxS. This report provides details on how the HBGV were calculated. For specific guidance at each contamination site the report indicates that community members should refer to the most current advice provided by their state or territory government.

IV. Food Standards Australia and New Zealand. PFAS and immunomodulation review and update. 2021. URL: https://www.foodstandards.gov.au/sites/default/files/publications/Documents/PFAS%20and%20Immunomodulatory%20Review%20and%20Update%202021.pdf

A literature review on updated evidence on immunomodulation since the findings from the enHealth Guidance Statements in 2018. The final conclusion of the report is that immunomodulation is unsuitable as a critical endpoint for quantitative risk assessment for PFAS.

The review provides four recommendations for future epidemiological studies to increase certainty about the PFAS exposure and impaired vaccine response, increased susceptibility to infectious disease and hypersensitivity responses, as wells as further research on the biological basis of immunomodulation by PFAS, through *in vitro* approaches and animal models:

- Prospective rather than cross-sectional studies.
- Studies examining antibody response to the same vaccine, across different populations, and correcting for potentially confounding variables, including other environmental chemicals with immunological properties.
- More studies examining a range of immunological endpoints rather than measuring only antibody titres.
- Studies examining more specific infectious diseases, with medical records confirming the diagnosis, and not confined to diseases requiring hospitalization.

V. New South Wales Department of Health. PFOS and PFOA factsheet. 2017April 3. URL: https://www.health.nsw.gov.au/environment/factsheets/Pages/pfos.aspx

A website that provides basic information about PFAS, exposure sites in NSW, exposure pathways and effects on human health. The page also provides precautionary health advice including TDIs, how to minimise exposure and advice to continue breastfeeding.

VI. New South Wales Environmental Protection Authority. The NSW Government PFAS Investigation Program. 2023 November 21. URL: https://www.epa.nsw.gov.au/your-environment/contaminated-land/pfas-investigation-program

A webpage that has an interactive map of PFAS contaminated sites across the state. This page has information about sampling being conducted, the draft PFAS National Environment Management Plan (version 3), and links to a fact sheet with similar information and the NSW DoH. The webpage also has sub-pages with information about the NSW PFAS Expert Panel, the PFAS investigation process and a the PFAS investigation program FAQs.

VII. Northern Territory Food and Safety. Fish and bush food containing PFAS chemicals. 2018 September. URL: https://nt.gov.au/industry/hospitality/accommodation-and-food-

businesses/food-safety-and-regulations/food-contamination/fish-and-bush-food-containing-pfas

A webpage designed for community members providing information about local produce in contaminated areas of the NT. Fact sheets for fishing in Darwin and Katherine are provided, and additional fact sheets are provided for bush food consumption in Katherine.

VIII. Northern Territory Environmental Protection Authority. PFAS. 2023 June 5. URL: https://ntepa.nt.gov.au/your-environment/pfas

A webpage providing basic information about PFAS for NT communities. This page give details about the NT response to the contamination and has details about the PFAS National Environment Management Plan (version 2). Links to the enHealth Guidance Statement and fact sheet are provided, as well as links to the factsheets on consumption of fish and bush tucker on the NT Food and Safety webpage.

IX. Queensland Department of Health and Wellbeing. Per- and poly- fluoroalkyl substances (pfass) factsheet. 2018 April 2018. URL: https://www.qld.gov.au/health/condition/health-consumer-information/poisonings-and-chemical-exposures/per-and-poly-fluoroalkyl-substances-pfass-f

A webpage providing basic information about PFAS to the Svennson Heights community, including what PFAS are, exposure pathways, effects on human health and how to reduce exposure to PFAS.

X. Queensland Department of Environment, Land and Water. PFAS in Queensland. URL: https://www.qld.gov.au/environment/management/environmental/incidents/pfas

A webpage providing information to the Queensland community on PFAS site investigations. The page also as some basic information about PFAS, the firefighting foam management policy and PFAS managements resources and guidelines.

XI. United Nations Environment Programme. Stockholm Convention. 2019. URL: https://www.pops.int/Home/tabid/2121/Default.aspx

The Stockholm Convention on Persistent Organic Pollutants (POPs) is a global treaty adopted in 2001 under the auspices of the United Nations Environment Programme. The treaty aims to protect human health and the environment from the harmful effects of POPs, including PFOA, PFOS and PFHxS. Actions for parties include:

The use, production and import or export of POPs listed in Annex A, including PFOA (listed 2019) PFHxS (listed 2022) and their associated salts and compounds, must be prohibited.

The use, production and import or export of POPs listed in Annex B, including PFOS (listed in 2009), must be restricted.

Additionally, they must ensure stockpiles and wastes of all listed POPs are managed safely and in an environmentally sound manner.

XII. European Environmental Agency. Emerging chemical risks in Europe - 'PFAS'. 2023 May 25. URL: https://www.eea.europa.eu/publications/emerging-chemical-risks-in-europe

A short, online assessment (briefing) on PFAS as an emerging chemical risk in Europe, published by the European Environmental Agency. The briefing summarises the known and potential risks to human health and the environment from PFAS.

References PFOA and PFOS, indicates limited information is available regarding uses and levels of specific PFAS across Europe.

Main sources of environmental PFAS contamination include production, consumer products, industrial waste releases, and reuse of sewage sludge as fertiliser.

Environmental distribution of PFAS is ubiquitous, with water pollution. Areas around industrial production, manufacturing and application sites have been found to be particularly contaminated by PFAS.

Routes of human exposure to PFAS include drinking water, food, consumer products and dust, maternal transfer. Describes blood concentrations from previous European studies.

Summarises current knowledge of effects of PFAS on human health, delineating "higher" and "lower" certainty.

Provides advice for consumer avoidance of PFAS, *"Decreased exposure to PFAS may be achieved by using consumer products from green labels and buying brands free from PFAS"*, with links to national institutions for specific consumer guidance.

Current action in Europe includes listing of PFAS by Stockholm Convention POPs, restrictions under EU POPs regulation, REACH SVCHs, and active monitoring in some countries.

XIII. HBM4EU. Per-and poly-fluoroalkyl substances (PFAS): What you need to know. URL: https://www.hbm4eu.eu/wp-content/uploads/2021/11/Factsheet_PFAS.pdf

A factsheet for the public providing information on what PFAS are, environmental distribution, exposure routes, potential human health effects with reference to the EFSA limits, exposure

reduction measures, European exposure with reference to human biomonitoring studies, HBM4EU actions, and the broader EU response to PFAS including the Stockholm Convention, with links to further information. The factsheet is written in plain language and includes illustrations and diagrams.

XIV. Swedish Chemicals Agency (KEMI). PFAS. November 2023. URL: https://www.kemi.se/en/chemical-substances-and-materials/pfas

A webpage describing PFAS, environmental risks, health effects, exposure in Sweden, legislation and regulation, and reporting. It is aimed at the public but provides links to further stakeholder specific information on PFAS.

Indicates that there is evidence that a few PFAS present a health hazard, with reference to PFOA and PFOS

Briefly describes available studies of PFAS and outlines that they are largely experimental animal trials, with reference to health effects found in these studies. Also describes observational epidemiological studies.

Describes legislation and regulation at national, EU and global levels. Sweden has joined several other EU Member States in starting work to develop a broad restriction proposal in Annex XVII to the REACH Regulation, covering all PFAS in addition to those already subject to regulation.

Links to webpage with guidance on finding further information on PFAS for specific stakeholders including drinking water producers, firefighting foam or PFAS product users, importers and distributers, food producers, regulatory and water authority workers, and private persons:

Additional information is available in Swedish at Swedish Chemicals Agency (KEMI). Guide för ansvar, kontroll och hantering av PFAS [Guide for responsibility, control, and management of PFAS]. URL: https://www.kemi.se/hallbarhet/amnen-och-material/pfas/guide-for-ansvar-kontroll-och-hantering-av-pfas

XV. Danish Ministry of the Environment, Environmental Protection Agency (EPA). Perfluoroalkyl substances: PFOA, PFOS and PFOSA. URL: https://www.kemi.se/hallbarhet/amnen-och-material/pfas/guide-for-ansvar-kontroll-och-hantering-av-pfas

A report prepared by DHI to document health-based quality criteria for PFOA, PFOS and PFOSA in soil, drinking water and groundwater. The report was prepared for and published

by the Danish EPA, most of the data were compiled from the EFSA, USEPA and Danish EPA. The report includes a general description of PFAS (environmental occurrence, production and use, human exposure, biomonitoring), toxicokinetics, human toxicology, animal toxicology, regulation (national, EU, and global), and tolerable daily intake and quality criteria.

PFAS are used in industrial and consumer products.

PFAS are present in the environment, are stable to hydrolysis and resistant to aerobic biodegradation. Available concentrations in the air, water, and soil in Denmark and neighbouring countries (Greenland, Norway) are provided.

Food/drink intake, with cereals and fish as major sources of PFOA, and house dust are listed as the two main human exposure routes. Mean exposure estimates for children and adults are provided.

Indicated that, at the time of writing, the current concentrations of perfluorinated substances in Denmark were unknown.

PFOA and PFOS are readily absorbed after oral exposure, and are found in the liver, kidneys and blood with lower levels in many other organs, including the central nervous system. PFAS can cross the placenta barrier. Metabolic elimination seems to play no relevant role for both PFOA and PFOS.

Occupational exposure to a chemical facility manufacturing APFO initially showed a statistically significant association with prostate cancer mortality, but an updated study with more specific exposure measures did not observe the same association.

Studies on PFOA and PFOS in the general population revealed associations with adverse outcomes such as decreased birth weight, immunotoxicity, and neurotoxic effects; however, regulatory bodies like EFSA and USEPA found insufficient consistency in the data to establish reference doses for regulatory purposes.

XVI. Agency for Toxic Substances and Disease Registry, United States Centers for Disease Control and Prevention. Per- and Polyfluoroalkyl Substances (PFAS) and Your Health. 2022 November 1. URL: https://www.atsdr.cdc.gov/pfas/health-effects/index.html

A webpage providing information to communities in the US, including a site map, the health effects of PFAS and what is being done about PFAS. Visitors to the page can sign up for a quarterly newsletter on PFAS progress. A link to resources provides fact sheets for clinicians, exposure pathways, effects on human health and how to reduce exposure to PFAS, details

about how to estimate levels of PFAS in your blood, exposure assessment, and Minimal Risk Levels and Environmental Media Evaluation Guides. Factsheets for specific communities that have known PFAS contamination are also provided.

XVII. Talking to Your Doctor about Exposure to PFAS website: ATSDR, Talking to your Doctor about Exposure to PFAS. 2022 November 1. URL: https://www.atsdr.cdc.gov/pfas/health-effects/talk-to-your-doctor.html

A webpage providing information for members of the public who are concerned about PFAS exposure on how to start a conversation with their doctor about it with key questions to ask. The webpage has six questions on PFAS exposure and health. Summary answers are provided under each question, with prompts to talk to a doctor about concerns. The webpage lists potential health effects of PFAS, and provides links to further information on the ATSDR and US EPA websites.

XVIII. PFAS Clinician Factsheet: ATSDR. 2019. PFAS: An Overview of the Science and Guidance for Clinicians on Per- and Polyfluroalkyl Substances (PFAS). URL: (https://www.atsdr.cdc.gov/pfas/docs/clinical-guidance-12-20-2019.pdf

A factsheet published by ATSDR for clinicians responding to patient concerns about PFAS exposure. The factsheet includes sections on PFAS basics, PFAS health studies, questions that patients may ask clinicians, and links to additional resources and references.

XIX. National Toxicology Program. 2016. NTP MONOGRAPH ON IMMUNOTOXICITY ASSOCIATED WITH EXPOSURE TO PERFLUOROOCTANOIC ACID (PFOA) OR PERFLUOROOCTANE SULFONATE (PFOS). URL: https://ntp.niehs.nih.gov/sites/default/files/ntp/ohat/pfoa_pfos/pfoa_pfosmonograph_508.pdf

A monograph produced by the NTP which reports the result of a systematic literature review evaluating the evidence on exposure to PFOS or PFOA and immune-related health effects to determine whether exposure to either chemical is associated with immunotoxicity for humans. The review integrated human, animal and mechanistic studies published up to May 2018 to draw conclusions on hazards of exposure to PFOS or PFOA.

XX. USEPA. Our Current Understanding of the Human Health and Environmental Risks of PFAS. 2023 June 1. URL: https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas

A webpage for the general public providing information PFAS as an environmental hazard. The webpage includes sections on the origins of PFAS, environmental distribution, exposure sources, human health effects, highly exposed groups, references to further federal and state government information sources on PFAS, and information on how to provide input on proposed government actions including links to the EPA regulations register. The webpage also includes a link to sign up to receive press releases and alerts on PFAS topics.

XXI. American Cancer Society. Perfluorooctanoic Acid (PFOA), Perfluorooctane Sulfonate (PFOS), and Related Chemicals. 2023 March 21. URL: https://www.cancer.org/cancer/risk-prevention/chemicals/teflon-and-perfluorooctanoic-acid-pfoa.html

A webpage providing members of the public information about PFOA and PFOS in relation to cancer. The webpage includes sections explaining what these chemicals are, whether they cause cancer with reference to studies in humans and laboratories, references to information from IARC and USEPA, exposure sources, current action in the US, precautionary measures to reduce exposure and whether testing for PFAS exposure is helpful for individuals.

XXII. WHO IARC. IARC Monographs evaluate the carcinogenicity of PFOA and PFOS. IARC News. 2023 Dec 1. URL: https://www.iarc.who.int/news-events/iarc-monographs-evaluate-the-carcinogenicity-of-perfluorooctanoic-acid-pfoa-and-perfluorooctanesulfonic-acid-pfos/

Also published as: Zahm S, Bonde JP, Chiu WA, Hoppin J, Kanno J, Abdallah M, Blystone CR, Calkins MM, Dong GH, Dorman DC, Fry R. Carcinogenicity of perfluorooctanoic acid and perfluorooctanesulfonic acid. The Lancet Oncology. 2023 Nov 30. DOI: https://doi.org/10.1016/S1470-2045(23)00622-8

A preliminary research article of the evaluation of the carcinogenicity of PFOA and PFOS by the IARC Monographs on the Identification of Carcinogenic Hazards to Humans Working Group in November 2023, prior to the release of further details of the scientific assessment in Volume 135 of the IARC Monographs in 2024. Classification of PFOA as a Group 1 carcinogen i.e., carcinogenic to humans, based on the following criteria:

- Sufficient evidence for carcinogenicity in experimental animal models for an increased incidence of a combination of benign and malignant neoplasms in both sexes of a single species.

- Sufficient evidence for carcinogenicity in mechanistic models for PFOA inducing epigenetic alterations and immunosuppression.
- Limited evidence for carcinogenicity in humans from epidemiological studies of kidney and testicular cancer, where a causal association between human exposure to PFOA and cancer is possible, however potential role of chance, bias and/or confounding could not be established.

Classification of PFOS as a Group 2B i.e., possibly carcinogenic to humans, based on strong mechanistic evidence for immunosuppression and epigenetic alterations. Evidence was classified as limited in experimental animals and inadequate for humans.

IARC Monographs are a framework for hazard identification for risk assessment. Classifications for PFOA and PFOS do not evaluate the risk of cancer across levels of exposure to the PFAS, such as differentiation between background exposure to PFAS in the general population and elevated exposure to PFAS in populations impacted by local environmental contamination. Further information on the IARC classification definitions is available at https://monographs.iarc.who.int/wp-content/uploads/2019/07/Preamble-2019.pdf.

Attachment D: Developing a Social, Economic and Natural Precinct

PFAS 2023/24 – 40521 Developing a Social, Economic and Natural Precinct

PFAS Independent Review Report

Defence Infrastructure Panel

Reference: 525970

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aurecon

Bringing ideas to life

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1 Introduction

1.1 Background

1.1.1 PFAS in Defence settings

Per- and poly-fluoroalkyl substances (PFAS) are historically used in various industrial and consumer products, notably firefighting foams, and particularly in military and aviation contexts. PFAS are highly persistent, as they don't readily break down in the environment and can easily accumulate.

The historical use of PFAS-containing firefighting foam on Defence settings has resulted in significant contamination to the soil, groundwater, and surface water in and around Defence settings, affecting residential, commercial, industrial, and agricultural land. The persistence and potential health risks of this contaminant has raised significant environmental and public health concerns.

1.1.2 Independent Review

The Independent PFAS Review is a response to these ongoing issues, with the purpose of exploring how the land can be used or repurposed. The objective of this process is to find equitable and efficient ways to use this land and stimulate industrial activity while supporting individuals and businesses affected by contamination. The PFAS Independent Review will submit a report to the Australian Government in early 2024.

The Review will include consideration of:

- Existing mechanisms for determining land uses in the context of PFAS environmental contamination,
- Jurisdictional considerations for making decisions about future land use within the different states and territories, including land zoning,
- Varying PFAS contamination management frameworks across different jurisdictions, and
- Profile of potentially impacted properties, and thresholds or criteria that would trigger an assessment of land use.

1.1.3 Williamtown SAP context

Special Activation Precincts (SAPs) are designated areas identified by the NSW Government with the potential to deliver a high level of regional or state-wide economic activity and job creation. Williamtown was selected as a Special Activation Precinct (SAP) by the New South Wales (NSW) State Government primarily due to its strategic location to Newcastle Airport and Williamtown RAAF Base. The planned 380 hectare industrial and defence precinct aimed to stimulate regional economic activity, particularly through defence and aerospace-oriented industry through activation of the land to the South of the airport. While the SAPs primary focus was not PFAS remediation, some options considered mitigation measures to avoid PFAS contamination exposure/impacts. Williamtown was originally selected as a SAP due to its strategic location and economic potential. However, ultimately the costs of development were prohibitively high due to hydrology, flooding, geotechnical, drainage and PFAS issues. In 2023, the SAP was cancelled by the NSW Government.

Whilst the SAP is not the focus of this report, its process and extensive investigations provide a valuable case study for understanding the complexities and opportunities at Williamtown and the details have informed the analysis of alternative land uses for PFAS impacted lands which is the focus of this study.

1.2 Purpose and scope of works

This report will support the final report submitted by the PFAS Independent Review to the Australian Government.

The primary purpose of this study is to undertake a high-level assessment of the opportunities for alternative land uses of PFAS impacted lands. This report also focusses on utilising the common process of precinct planning and master planning to create alternative land uses but with unique consideration to development in constrained and PFAS impacted communities.

The scope of this report includes:

- Provide an expert assessment of the concept for the Williamtown SAP including:
  - Key opportunities and constraints presented by the SAP,
  - Key assumptions underpinning the SAP,
  - Strategic review of the SAP process and options for alternative processes (lessons learnt) that could be applied to a Social, Economic & Natural Precinct (SENP) focussed around PFAS contaminated Land,
  - Review of PFAS Land management at Williamtown, and
  - Review of PFAS development frameworks and guidelines (adaptive management).
- Identify opportunities to develop a social, economic and natural precinct around RAAF Base Williamtown, based primarily on planning documents previously prepared by the NSW Government as part of the SAP,
- Develop principles for the use of PFAS contaminated land, using Williamtown as a case study for potential varying PFAS contamination management frameworks,
- Potential Application of SENP principles with a focus on Williamtown; and
- Testing of principles at Oakey and Tindal Social, Economic and Natural Precinct.

To support the PFAS Independent Review, this report endeavours to explore the concept of establishing a Social, Economic and Natural Precinct using Williamtown as a Case Study.

This project has sought to identify the key strategic drivers, addressing site constraints, and harnessing natural capital to unlock growth and economic potential. This report aims to provide insights and recommendations for the development and sustenance of a vibrant and diverse precinct, primarily focussed on driving alternative land use options for PFAS impacted lands.

1.3 Assumptions and limitations

The following assumptions are noted specific to this analysis/advice:

- The analysis in this report consists of strategic and high-level advice, further detailed assessment is recommended as outlined in Section 6 of this report.
- The analysis is based on publicly available studies. No consultation has been undertaken with any agency or third party as part of this study.

This report has been prepared by Aurecon Australasia Pty Ltd for the benefit of our client (PFAS Independent Review Team) and was prepared for the specific purpose as defined in Section 1.1.

Aurecon has used its reasonable endeavours to ensure that this document is based on information that was current as of the date of the document. Aurecon's findings represent its reasonable judgments within the time and budget context of its commission and utilising the information available to it at the time.

1.3.1 Reliance on data and information

In preparing the report, Aurecon has relied upon data, surveys, analyses, designs, plans and other information that is publicly available through other individuals and organisations, most of which are referred to in the report ('reference documents'). Except as otherwise stated in the report, Aurecon has not verified the accuracy or completeness of the reference information. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ('conclusions') are based in whole or part on the reference information, those conclusions are contingent upon the accuracy and completeness of that information.

Aurecon will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented, or otherwise not fully disclosed to Aurecon.

2 Williamtown Site Characteristics

Williamtown is located approximately 13.5km north of the Newcastle CBD in New South Wales, within the Hunter Region.

The Williamtown SAP is located within a portion of the lands of the Worimi people who are the original custodians of the Port Stephens area. The structure plan has been aligned with existing development adjacent to Newcastle Airport, Cabbage Tree Road to the south, Nelson Bay Road to the east and Newcastle Airport to the north. The road network connects to existing and planned roads with multiple access points from both Nelson Bay Road and Cabbage Tree Roads. Key developments nearby include RAAF Base Williamtown, Newcastle Airport, Williamtown Aerospace Centre and Astra Aerolab. The downstream RAMSAR wetland in Fullerton Cove, the Tomago Sandbeds and the PFAS plume are other factors in proximity to the Williamtown SAP which also impact the site.

Figure 2-1: Williamtown site characteristics (DPE SAP Structure Plan)

2.1 Williamtown site constraints

2.1.1 Flood and drainage

The proposed site for the Williamtown Social, Economic and Natural Precinct is low-lying and flat, exposing it to three different flooding mechanisms (see Figure 2-2) including:

- Local flooding on the site and neighbouring land which slowly convey across the lower lying areas.
- Regional Flooding resulting from rain in the upper Hunter flowing through to Williamtown via the Hunter River and Tilligerry Creek.

- Tidal Inundation due to tides in Fullerton Cove and Port Stephens.

Any development pads are required to provide flood immunity above the surrounding flood levels. The required flood immunity level typically considers 1% annual exceedance probability (AEP) flood events and additional freeboard, probable maximum flood (PMF) evacuation routes and climate change resilience such as sea level rise up to 2100.

As filling occurs, flood waters are displaced and must be managed. Flooding is considered the most challenging constraint for development.

2.1.2 Geotech and settlement

The ground conditions around Williamtown are poor often consisting of compressible materials (see Figure 2-2) which require additional considerations such as bespoke ground preparation for high load structures. Preparation techniques including surcharge loading are required to accelerate ground consolidation and minimise post-development settlement which has significant time and cost implications. Finally, the importation fill has procurement considerations as the quantity of suitable fill is not readily available from a single local source. The truck haul route, local road network and viable stockpile locations were considered within the overall bulk earthworks strategy and ultimately the cost of importing the substantial volume of fill. Ultimately the scale of earthworks required to support flood free pads; as well as managing the settlement issues, is likely to have resulted in very challenging cost and constructability implications for the SAP. Future development options could consider uses that are compatible to the ground conditions but may not align with high structural load uses.

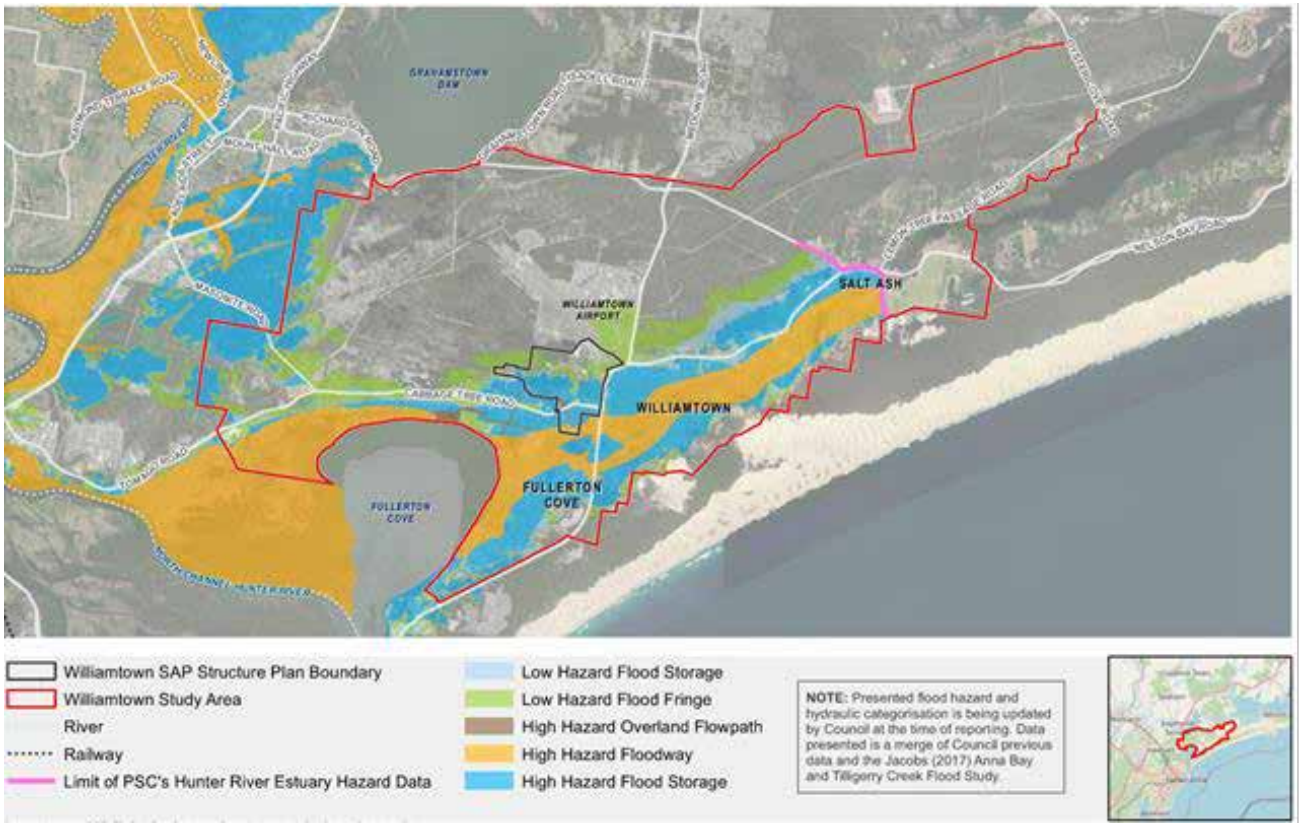


Figure 2-2: Port Stephens Council Flood Hazard Map (Source: Williamtown SAP (Aurecon 2023))

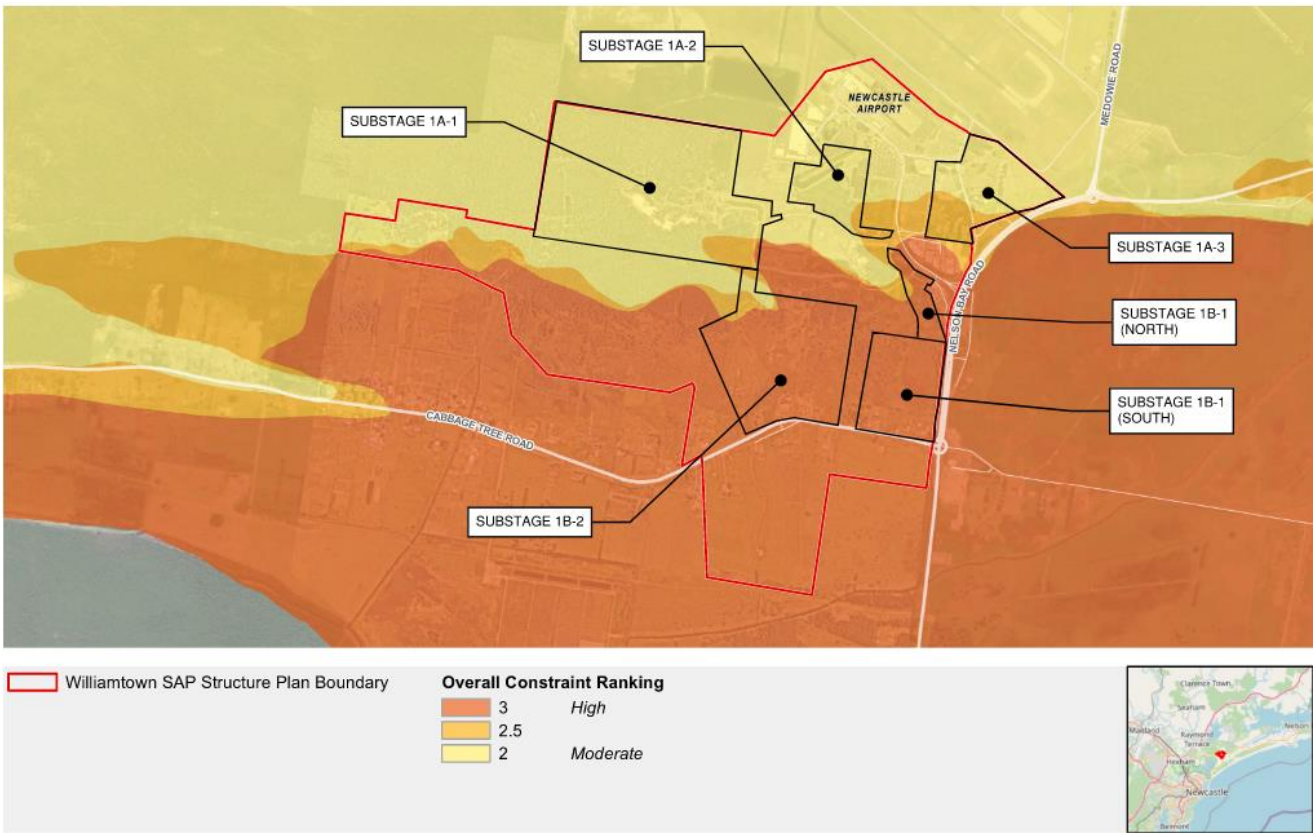


Figure 2-3: Geotechnical Constraints Map (Source: Williamtown SAP (Aurecon 2023))

2.1.3 Biodiversity

The existing Williamtown site includes the following biodiversity items:

- 7 plant community types (PCTs) of varying condition and sizes.
- A number of high threat weeds, primary weeds and weeds of national significance.
- At least one threatened flora species with assigned ecosystem credits.
- A diverse range of birds, mammals, bats, reptiles and amphibians, some of which are classified as threatened species with assigned ecosystem credits.

Overall, the site includes sensitive areas of significant diversity value, which where possible should be avoided or impacts minimised. Examples include within the environmental protection area where the development would have potentially serious and irreversible impacts to species and ecological communities.

2.1.4 PFAS contamination

Note: PFAS zones referred to in this section refer to the NSW EPA administered PFAS Management Area and the associated precautionary advice.

The Williamtown SAP investigation area includes properties impacted by PFAS contamination (see Figure 2-4). Landholders may have suffered loss or damage as a result of this contamination.

Immediately south of the base and extending to Cabbage Tree Road is the Primary Management Zone, this area contains the highest groundwater PFAS concentrations. The groundwater plume extends south from the base covering this area, being driven by hydraulic head from Lake Cochran on the south boundary of the Base. Between Cabbage Tree Road and Fourteen Foot Drain to the south, and from the eastern base boundary extending east along Nelson Bay Road to Tilligerry Creek is the Secondary Management Zone, and the remainder of the areas adjacent are classified as the Broader Management Zone.

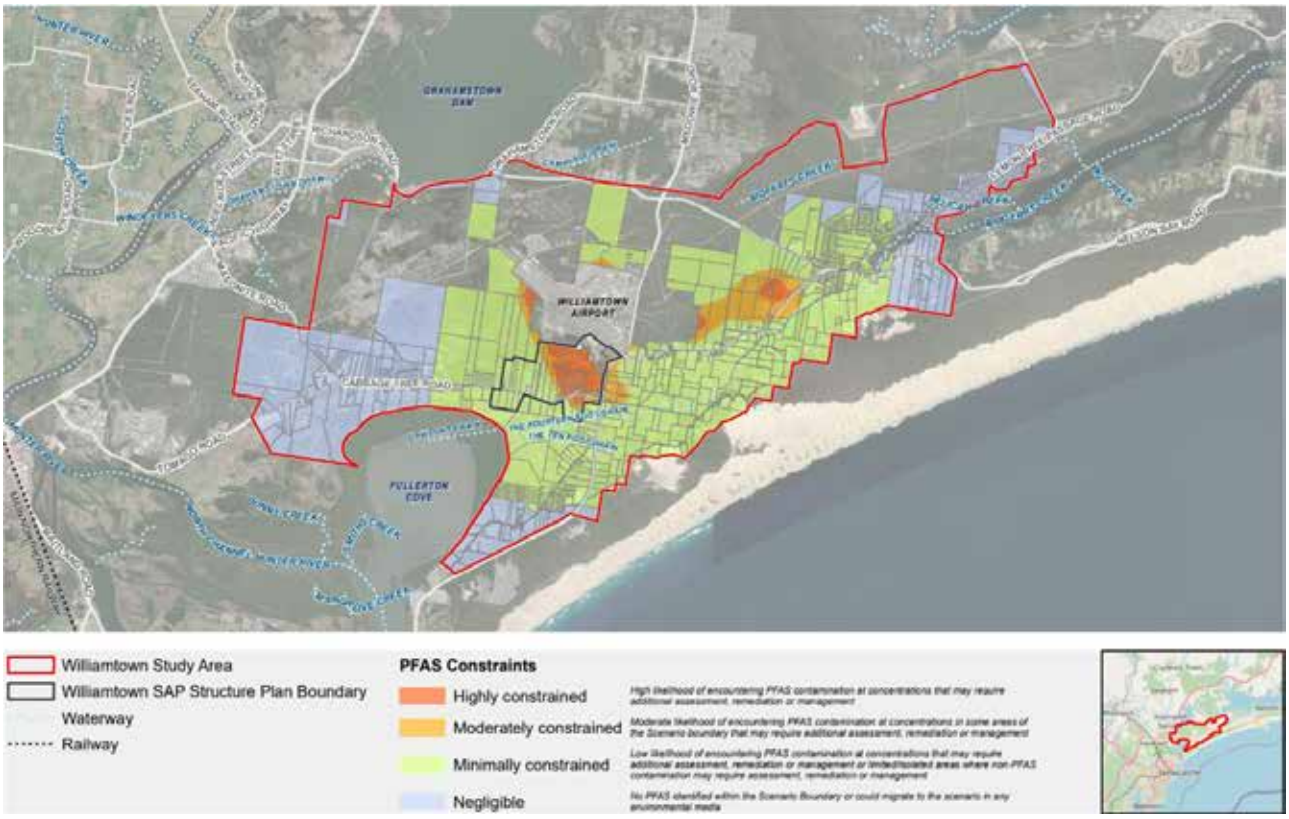


Figure 2-4: PFAS Constraint Regional Map (Source: Williamtown SAP (Aurecon 2023)) Special Activation Precinct Program Case Study

2.2 SAP program

Special Activation Precincts (SAPs) are designated areas identified by the NSW Government with the potential to deliver a high level of regional or state-wide economic activity and job creation. SAPs leverage State Government involvement in the planning, development, and investment process to accelerate the development of precincts. This process aims to overcome barriers that, without government involvement, could have made such development challenging or unattainable. The precincts aim to be sustainable business hubs which stimulate job creation and economic development in regional areas.

Figure 2-5: NSW designated Special Activation Precinct Map (Source: Special Action Precinct Program (Regional Growth NSW Development Corporation 2023))

2.2.1 Program purpose and principles

The purpose of the SAP program is to create streamlined planning pathways, underpinned by extensive environmental and infrastructure investigations which inform the master planning process with the goal of securing investment in catalyst infrastructure and to stimulate economic growth. SAPs aim to attract significant private investment, create jobs, and offer benefits like low-cost green energy, shared infrastructure, and onsite renewable energy.

2.2.2 Program objectives

The SAP program has 6 core objectives:

- Drive economic growth and job creation in regional NSW.
- Diversify regional economies.
- Build on regional strengths.
- Attract and retain skilled workers.
- Promote innovation and collaboration.
- Strengthen regional communities.

2.2.3 SAP planning pathway framework overview

The planning approval pathway for SAPs in NSW follows a unique process established by the Activation Precincts State Environmental Planning Policy (SEPP), aiming to streamline development while upholding quality and environmental protection. The following parts of the special activation precinct planning framework highlight the specific policies and planning instruments involved:

- **Upfront planning**: A Strategic Environmental Impact Assessment identifies opportunities and constraints for the precinct. A Master Plan outlines the vision, land uses, infrastructure needs, and development constraints, guiding the Delivery Plan(s) and development proposals.
- **Infrastructure planning**: A delivery plan outlines the specific infrastructure required to support the development, for example, roads, utilities, stormwater management.
- **Development proposal**: Development proposals must be consistent with the Master Plan and in compliance with Principal Development Standards set out in the SEPP.
- **Approval pathway**: Proposals compliant with the Master Plan and Principal Development Standards access a simplified pathway through a Proposal Certificate issued by the Regional Growth NSW Development Corporation. Non-compliant proposals follow the standard development consent process.
- **Design guidelines**: Design guidelines provide specific guidance on building design, landscaping and amenity, ensuring visual coherence and quality within the developed area.

3 Creation of a Social, Economic and Natural Precinct (SENP)

The previous sections outline the historical context of Williamtown and its many complexities and opportunities. The following sections seek to explore the opportunity to create a 'Social, Economic and Natural Precinct' (SENP). The concept of the SENP has been developed to be agnostic of location but equally has been tested in this report against Williamtown.

When reviewing the SAP program, Williamtown was originally selected as an SAP primarily due to its location and to meet the growing needs of Williamtown RAAF Base and Newcastle Airport. It's strategic drivers and intention were to leverage and unlock jobs and economic potential (a fundamental principle of the SAP program). Ultimately the costs of developing the Williamtown SAP were prohibitively high due to the hydrology, flooding, and drainage issues at Williamtown, relative to the proposed land uses. As such, the decision was made not to proceed with the SAP.

The overarching aim of the SENP is to explore alternative land use options for PFAS impacted communities using the concept of the Social, Economic and Natural Precinct as a vehicle. This presents a unique and fundamentally different objective for the SENP in contrast to the SAP. When expanding out the objective of the SENP we have developed the following outcomes sought by the SENP. These have then been translated into a set of guiding Principles. The objectives and principles of the SENP embody the aims of the PFAS Independent Review:

- To identify opportunities for development whilst considering co-existing and/or repurposing of PFAS impacted lands. Opportunities should not be limited to traditional 'Highest' value land uses but to primarily explore best complementary/compatible use of PFAS lands.
- To identify the economic and social needs of the region and determine catalytic industries that could act as a pillar for growth and change, encourage social equity and add value to encumbered properties.
- To identify strategic opportunities to harness the best use of the land over multiple time horizons, acknowledging constraints, supply/demand, evolutive constraints such as PFAS, investment opportunities and Unique Value Propositions.
    - To acknowledge some PFAS affected areas may be prohibitive to development in the short term, however there may be opportunities to unlock downstream potential following remediation activities and as the environmental constraints evolve. The fate and transport of, and risks associated with, PFAS are well established currently, particularly around the RAAF Williamtown Base. Defence continues to remediate the PFAS in soil and water on and off Base and these efforts will be expanded in the near future to additional off-site locations. These ongoing efforts will likely contribute to a reduced risk profile at the anticipated timeframes of any future construction.
- To balance economic growth and environmental preservation by harnessing and enhancing the natural capital of the area.
    - Encourage a sustainable and coordinated development approach, prioritising strategies that promote natural, biodiversity and ecological resilience.

The above objectives, whilst not exhaustive, have been outlined to provide guidance as to what the SENP aims to address. We have then expanded out these objectives into a set of guiding principles that guide the implementation methods of the SENP.

The establishment of a Social, Economic and Natural Precinct presents a unique opportunity to transform PFAS impacted sites, adding salient and intrinsic value to impacted communities whilst driving regional economic growth, social and natural enhancement. The Precincts aim to drive value creation across all levels of site potential, including on (often overlooked) constrained sites. Important to this process is that master planning of communities is founded on clear, value-based principles that seek to build on current master planning and land development best practice.

Based on our review of the overarching purpose and consideration of key economic drivers, guiding development principles were established to reinvigorate Williamtown and unlock its potential with a holistic consideration.

3.1 Proposed development principles

Figure 3-1: Development Principles "the what"

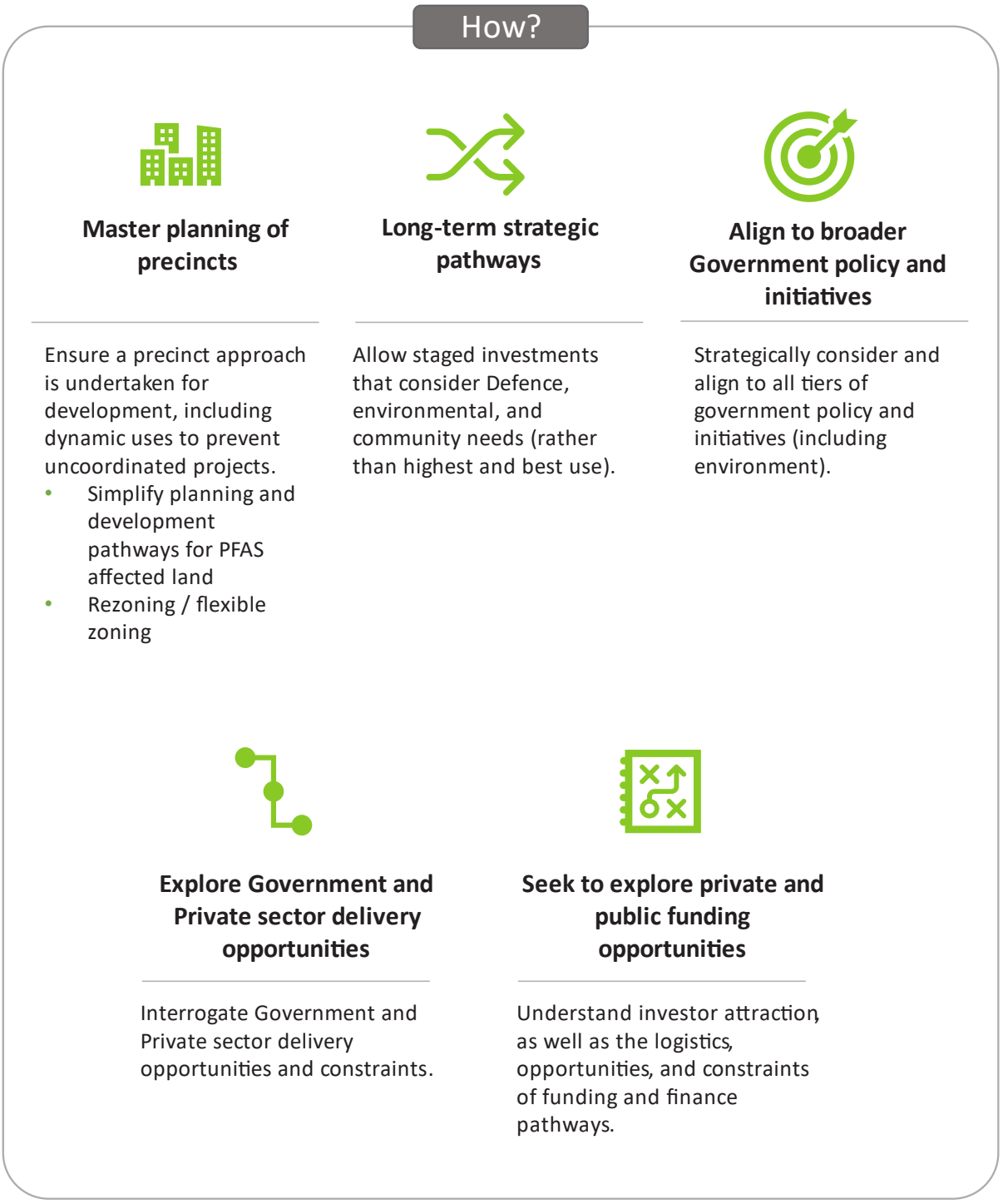


Figure 3-2: Development Principles "the how"

3.2 Development principles discussion

The following development principles of a Social, Economic and Natural Precinct are location agnostic and aim to be applied across any region.

3.2.1 Community benefit

Community benefit is the primary principle and purpose for the project. It defines its uniqueness as the application of development solutions specifically to PFAS impacted land and the potential to add value to landowners, community & industry through social and economic drivers only available through initial Government intervention.

This principle is the primary test point to which all solutions/opportunities must address. A Unique Value Proposition (UVP) for each region must be defined and founded in evidence-based projections.

Typically, the drivers of growth are categorised into four typologies, namely:

- Demographic shifts,
- Economic factors,
- Regulatory and policy changes, and
- Social, environmental and lifestyle preferences.

For each region, a UVP will be determined with a focus on opportunities for repurposing PFAS impacted lands. This is not to be limited to traditional 'highest' value land uses but primarily explore best complementary/compatible use of PFAS lands to meet regional UVP natural or emerging advantages and objectives.

Social equity is to be a foundation of this principle's evaluation. PFAS impacts often cover large areas. It is acknowledged that creation of a new regional precinct may favour some sites over others, and this is typical in land use planning. Opportunities should be explored to further consider what social equity initiatives could be put in place.

These could entail:

- Sharing land value uplift, possibly through a value capture mechanism (or similar).
- Opportunities to expedite remediation for the region.
- Government led investment in infrastructure (including social) with regional investment.

3.2.2 PFAS co-existence planning

The PFAS co-existence planning process will explore opportunities to streamline planning approval pathways process for PFAS impacted land including standardised land management processes for PFAS avoidance and co-existence.

Mapping risks of exposure, impacts to industries, and land use will support the development of a guidance framework based on level of contamination, nature of contamination at the site, current land use and future land use options that allow for co-existence. These would be based and built upon existing guidance documents developed by the Heads of EPAs (HEPA), Defence and other relevant international sources. The planning process will also limit the risks of future development precluding remediation activities.

The project should explore opportunities to assess and designate regions of the precincts where development of PFAS land is economically viable and practical to do so without causing adverse impacts to neighbouring communities/region or the environment. This will provide clarity to landowners/investors where development may be:

- Viable with no mitigation measures needed.

- Viable with little mitigation measures.
- Viable with significant mitigation measures.
- Long term viability following remediation (these may potentially be sites with where levels of PFAS exposure are high or their development may cause mobilisation of PFAS).

3.2.3 Defence capability enhancement.

In parallel to the community benefit principle, PFAS impacted communities adjacent to Defence establishments provide a unique opportunity for Defence to facilitate a number of growth initiatives for the local region and economy. Where permissible opportunities should be explored by Defence in the following areas:

- Re-evaluating programmatic and sustainment initiatives that could be delivered off Commonwealth land in the public domain (on PFAS impacted sites), potentially holistically by the private sector. This could include defence adjacency needs such as key worker housing, social services, defence industry (primes).
- Re-evaluating wider Defence programs for their applicability to the region, specifically when viewed with addressing PFAS impacted lands.
- Exploring opportunities for Defence to stimulate growth of supporting adjacencies and/or opportunities to remove barriers to growth through catalytic investment (Opportunities for Defence to invest in infrastructure to unlock development or acquisition of the priority development zones/areas).
- Opportunities for Defence to undertake investment attraction activities to stimulate growth in the regions.

3.2.4 Government and private sector funding

Explore economic and social needs of the region to determine catalytic industries that could act as a pillar for growth and change. The following opportunities could be explored:

- Regional demands for supply based on current needs across all sectors relevant to a region.
- Review of current government and private sector major initiatives and catalytic programs in the regions (Examples include Renewable Energy Zones, Inland Rail, Supply chain efficiencies, Primary Industry needs).
- Review of emerging trends and government strategies.
- Review of social and community needs, including Indigenous engagement.
- Review of environmental needs and requirements for the region. Understanding ecosystem and biodiversity needs of the region.

3.2.5 Natural asset enhancement

The concept of a Social, Economic and Natural Precinct involves balancing economic growth with environmental preservation and enhancement. Consideration of natural assets and constraints is essential in recognising the intrinsic value of natural capital. Natural capital encompasses the resources and services provided by the environment, understanding the local ecosystems, topography, and climate is fundamental in designing sustainable precincts.

Biodiversity and ecological resilience should be at the forefront of decision-making processes. This includes identifying and protecting critical habitats, considering the needs of diverse species, mitigating PFAS impacts, and implementing measures to maintain or enhance biodiversity.

By understanding the natural assets and ecosystems, precincts can serve as models for environmentally conscious development and unlock economic opportunities, such as:

- Biodiversity offsets.

- Renewable energy.
- Conservation activities, such as green corridors and protected areas.

3.2.6 Master planning of precincts

The Government will sponsor and lead master planning studies based on the founding 'what' principles that support the development of a Social, Economic & Natural Precinct across PFAS impacted communities. Centrally co-ordinated master planning will help ensure that the precinct UVP is maximised and will build agglomeration benefits unachievable in an open development. The Government, via the master planning studies, will:

- Explore opportunities to streamline development pathways and development of a simplified PFAS delivery strategy.
- Explore opportunities to facilitate flexible rezoning processes to allow long term development adaptation as PFAS impacts change and market factors evolve (i.e. long-term Defence programs).
- Identify constraints and opportunities across the study areas and in parallel with market analysis will determine optimum options for short-, medium- and long-term horizons.
- Identify 'market failures' and opportunities for intervention through Government and private sector intervention.
- Explore flexible rezonings in fringe lands to enable certain (but limited) types of development to occur through a streamlined process, noting that these lands may not be required to strategically meet market needs (and may not be optimally located) but could support social and /or environmental projects (such as biodiversity offsetting).

3.2.7 Long-term strategic pathways

Develop staged rezoning and delivery plans that consider both long-term growth and demand over time but also allow for flexible land use changes over time providing opportunities for near term value creation with options for longer term alterations and demand grows. It acknowledges that some sites may not be suitable or required for their highest and best use from the onset but allows for interim development to occur creating value for landowners.

3.2.8 Align to broader Government policy and initiatives

Explore opportunities for intergovernmental coordination and collaboration with Commonwealth/State led and funded investigations, master planning and statutory planning.

- **Commonwealth/Defence:** Project Sponsor, Defence led Investment Attraction, PFAS Expedited Planning and Design Guidelines, Potential for Catalytic Investment to enable development, business case for Commonwealth initiatives (supported by delivery strategy).
- **State Government:** Planning Framework and Statutory Amendments (as required), Master planning, Delivery Strategy and Investment Attraction, business case for state initiatives (supported by delivery strategy and incorporating Commonwealth initiatives).
- **Local Government:** Investment attraction, local planning amendments/instruments, proponent in master planning.

Explore opportunities for the masterplans to support broader non-region-specific Governmental initiatives such as net zero, resilience, environmental, decarbonisation etc and to support/promote opportunities for First Nations peoples.

3.2.9 Explore Government and private sector delivery and funding opportunities

Develop delivery plans and strategies for activation and implementation. Traditional approaches include, in increasing level of Government involvement:

1. Organic private sector growth**:** Rezoning and expedited planning pathways, no other Government intervention.
2. Government led investment attraction and contribution schemes.
3. Government led investment in catalyst infrastructure/development and strategic acquisition (as required).
4. Government and private sector led development (PPP's etc).

The above would be evaluated and supported through the traditional business case process to discern the optimum balance of Government vs private sector involvement and investment.

4 Project Process Framework (Founded on Land Use Planning Best Practice and SENP Principles)

Based on the development principles the following overarching Government process could be implemented to enact the Social, Economic & Natural Precinct. It consists of a blend of three tiers of Government involvement and contribution whist aiming to prioritise and make social equitable the process of evaluating PFAS impacted lands for renewal/development.

A unique component of the approach is the adaptive planning process to provide a default position towards land use development on PFAS impacted sites that may not fall within an immediate or strategic near-term need. Traditionally master planned communities are staged to leverage highest and best use ultimate development and remaining areas are left stagnant until such time as the demand catches up. However, a socially equitable option could include interim land use sub-options that would be permissible and contribute towards the social and environmental fabric of a region, they can co-exist with the PFAS (or other environmental challenges) until such time as land is needed for its highest and best use.

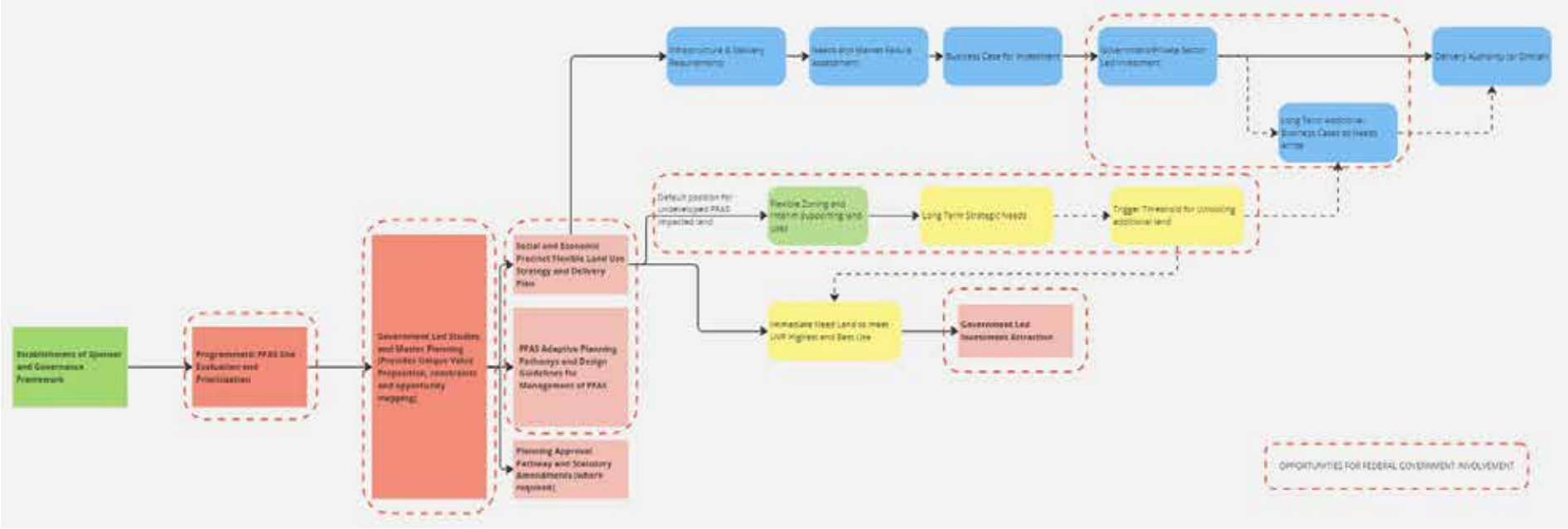


Figure 4-1: Example Project Process Framework

5 Social, Economic & Natural Precinct – Potential Land Use Typology

When exploring the opportunities to apply the SENP principles to development as well as ensuring a well-considered and socially inclusive master planning process, we have identified the potential need for three levels of development planning zones / typologies to deliver the precinct vision. Each of these development typologies serves as a vehicle to enable the project objectives.

The primary focus of these categories and where they are applied supports the **"Why"** principles as outlined above. Of particular focus is application to PFAS impacted communities. It is acknowledged that the master planning process for each region will need to fit into the strategic and local development frameworks for regional consistency (such as the Hunter and Central Coast Regional Plan 2041 in the case of Williamtown). As such the proposed approach, whilst also applicable to non-PFAS land, has been focussed on solely on addressing PFAS impacted communities. It is not uncommon for master planned communities to focus solely on the highest and best use industries for a region. However, a core function of the SENP is to provide a mechanism for all areas contribute even in the smallest way, whilst appropriately considering constraints. Further exploration could be undertaken to expand the remit and view of the SENP to encompass neighbouring communities but has not been the focus of this report.

5.1 Typologies

The following zones and associated typologies have been developed that seek to cover all possible development areas with varying levels of Government intervention. Whilst not listed as a 'fourth' category it is acknowledged that some areas will not be possible to develop due to their constraints and/or environmental significance, these areas will be excluded as part of a masterplan assessment.

Priority Development Zone: The Priority Development Zone seeks to support and foster the highest and most strategic use of the land; these are land uses that support a particular regions strongest Unique Value Proposition (UVP). In the case of Williamtown, this strategic need and UVP aligns with the following market needs:

- Defence related industries,
- Aerospace industry (including manufacturing and logistics),
- Freight and logistics,
- Education; and
- Innovation and entrepreneurial industries.

It is important that these needs are strategically located to maximise their potential and economic contribution. The Priority Development Zone(s) would seek to cohesively define development locations and layouts to prioritise these market needs through Government led studies, masterplans, flexible rezoning and coordinated infrastructure strategies (with potential Government investment). The Priority Development Zone is the core master planned area of a SENP and follows a traditional master planning and rezoning process (in NSW context). The Priority Development Zone has the strongest alignment to the principles as outlined in Section 3.

The following two development areas seek to define a use case for land that sits outside the Priority Development Zone that may be constrained, poorly located or not required to fulfill the development needs of the Priority Development Zone. When considering conventional master planning and rezoning processes, the land outside of the Priority Development Zone would traditionally be left in-situ in its current zoning/use and ultimately excluded from the overall development of an area. However, a SENP seeks to consider further opportunities to add value to PFAS impacted communities and contribute overall to the wider regional needs. This land outside of the Priority Development Zone has a productive value to the region but it is

acknowledged that the sites are often more heavily impacted and/or lack strategic connectivity. As such a unique subset of development uses may still be possible.

The following two development zones consider opportunities to explore use cases for the land outside the Priority Development Zone but within the PFAS impacted community.

Strategic Overlay Zones: The purpose of the Strategic Overlay Zones is to provide opportunities for development to occur outside the Priority Development Area and generally within the PFAS impacted community. These areas would be guided by strategic structure plans (or masterplans where relevant) that align with the wider UVP of a region and ensure congruent development and connectivity. These areas would largely support secondary and lower order UVP opportunities that would not conflict/detract with the Priority Development Zone. These areas may be partially constrained. The intent of the strategic overlay is to encourage development but provide a level of strategic guidance, limit development to uses that appropriately compliment the UVP and are compatible with the respective constraints. The approved land uses could be captured in another flexible zoning.

In the Strategic Overlay Zones, developers would be required to show that their development meets the strategic objectives of the structure plan and that their development is compatible with the constraints of the area, whilst minimising land use conflicts. As development in these locations may be geographically distributed; with possibly many development fronts, it is therefore envisaged that any developments (and all associated required infrastructure) would be proponent led. There is an opportunity for Government to facilitate the strategic planning process.

Interim Zones: Interim Zones identify are land areas that sit outside both the Priority Development and Strategic Overlay Zones. They are likely to be heavily constrained and/or are sensitive lands. They generally have very limited development options but may have some development potential provided they are compatible with the site constraints and; similar to the Strategic Overlay Zones they meet the strategic needs of the UVP. In these locations it is acknowledged that some constraints may evolve with time and/or that new technologies may improve/remove the site risks. An example of these locations are sites that have onerous PFAS constraints but post remediation these lands could be transitioned to higher order Zones such as the Strategic Overlay Zone. In these locations the intent is to explore interim uses for the land that may add additional value but ultimately do not prepclude longer term use of the sites. The general planing approach and requirements of the Strategic Lands would apply but a smaller subset of development opportunities would be permissible. These areas also offer a significant opportunity for sustainable, low impact, nature based and cultural solutions.

The following sections explore the applicability of the land use zones and associated typologies to Williamtown and provide a greater breakdown of their purpose, benefits, and integration of the guiding development principles.

A greater breakdown of the applicability of the principles to Williamtown has been provided in the appendix.

5.2 Potential land use typology – Williamtown

Social, Economic & Natural Precinct

Williamtown Proposed Zones

Priority Development Zone

- Has a detailed master plan with strong Unique Value Proposition
- Least constrained strategic lands
- Fast tracked rezoning process
- Addresses the Unique Value Proposition of the region
- Coordinated with infrastructure
- Focus of investment and Government intervention in enabling works

Strategic Overlay Zone

- Based around a strategic structure plan (or masterplan) to ensure a congruent and flexible Development
- Preliminary rezoning that addresses/acknowledges major site constraints and determines permissible/compatible land uses based on the UVP
- Requires developers to seek approval under a compliant/complying development approach. Ensuring statutory compliance and consistency with the Strategic Overlay structure plan, UVP and permissible land uses.
- Developments are complimentary/compatible with the Site Constraint(s).
- Developer led infrastructure provision. Limited Government intervention, market led

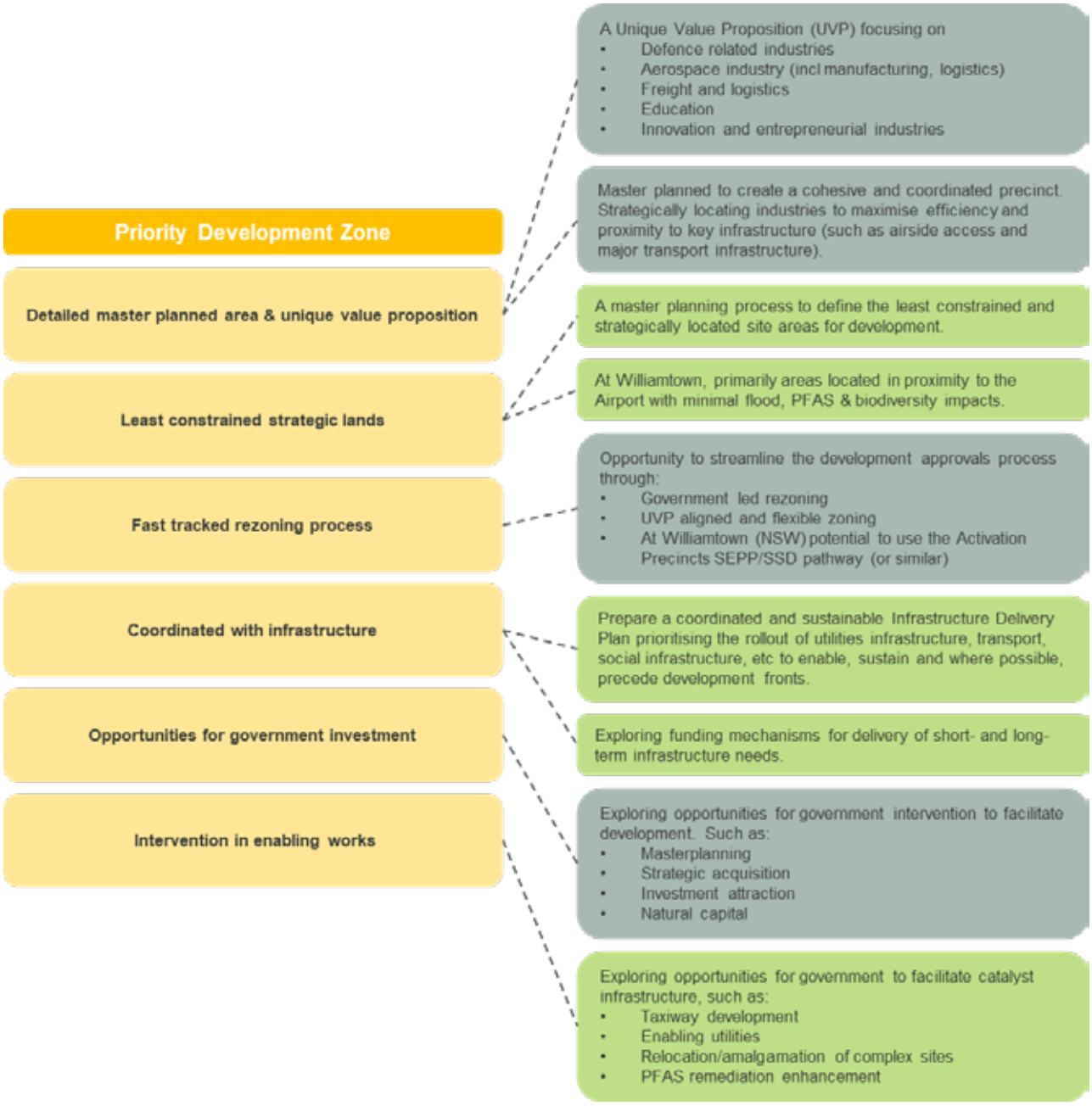
Interim Zones

- Areas of high development constraints and/or environmental significance.
- Potential development opportunities restricted to constraint compatible land uses.
- Development typology aligned with UVP.

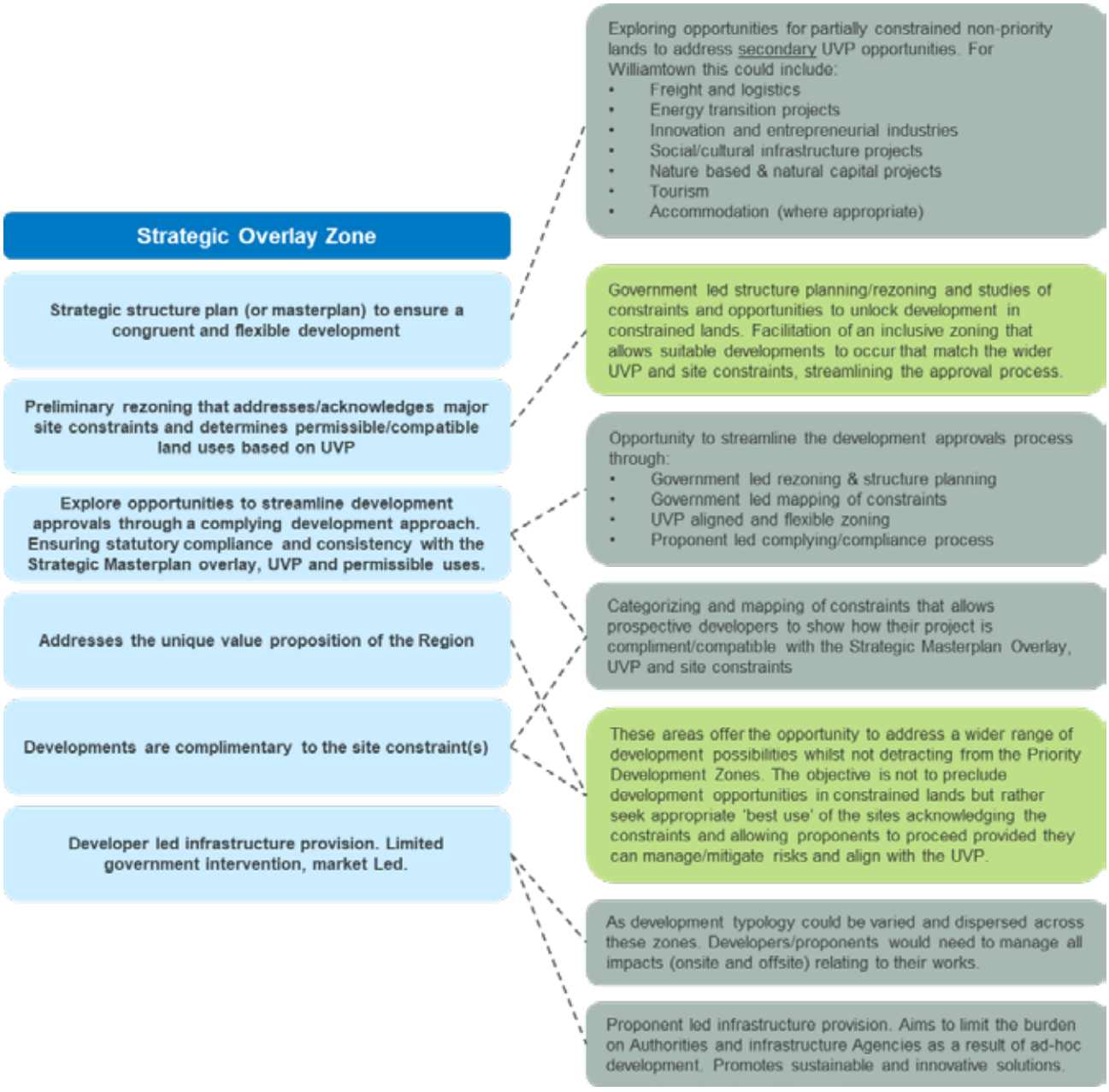
Principles

- Community benefit
- PFAS co-existence planning
- Defence capability enhancement
- Government and private sector initiatives
- Natural Asset Enhancement
- Master planning of precincts
- Long-term strategic pathways
- Align to broader Government policy and initiatives
- Explore Government and Private sector delivery opportunities
- Explore funding opportunities

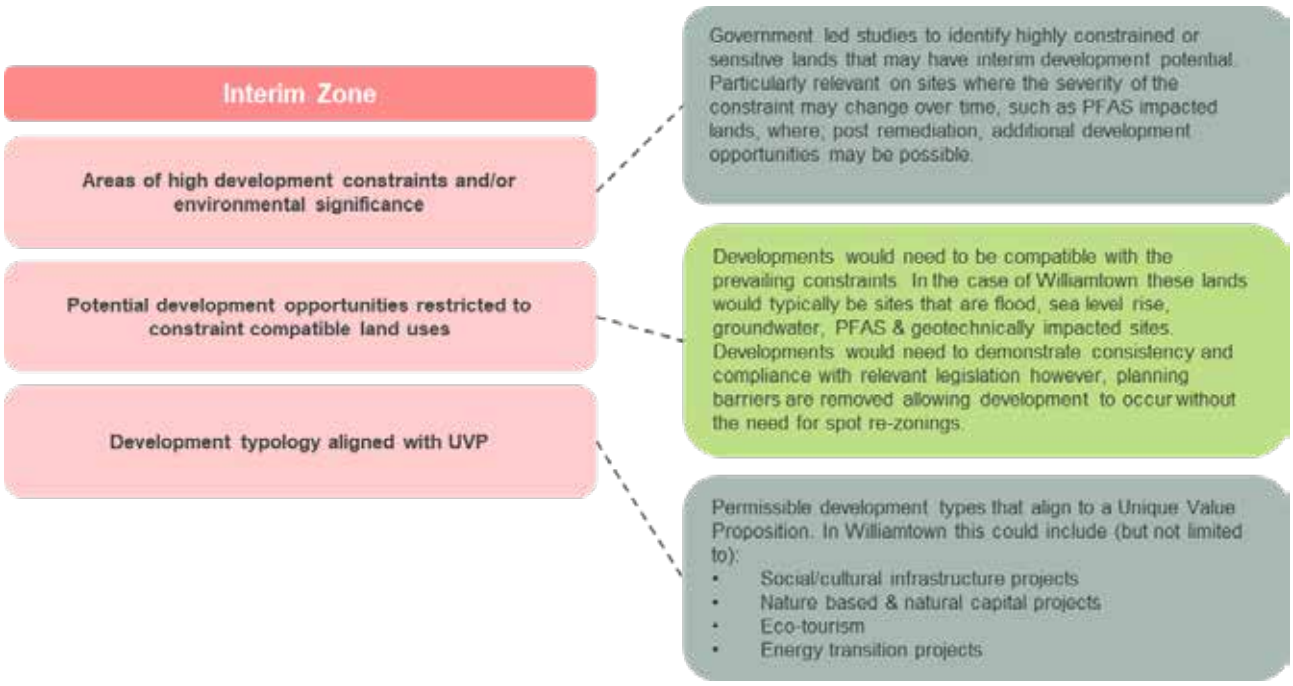
5.2.1 Priority Development Zone – Williamtown



5.2.2 Strategic Overlay Zones – Williamtown



5.2.3 Interim Zones - Williamtown



5.3 Land use planning implications

NSW planning framework

The planning system consists of a hierarchical arrangement of legislation, policy and consent authorities which govern them to facilitate land use planning and approvals that can be reviewed for potential intervention to support the development of PFAS affected land in and around the Williamtown SAP.

In NSW, the planning framework is underpinned by the *Environmental Planning and Assessment Act 1979 (*EP&A Act). Statutory instruments are made and amended under the EP&A Act. It also plays a role in the implementation of the regulatory regime established by the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. Key public authorities include the Department of Planning, Housing and Infrastructure (DPHI), Environmental Protection Authority (EPA) and local Councils.

The NSW planning system is divided into two broad areas: land use planning and development control. Land use planning sets strategic short and long term social, environmental and economic objectives for an area. This is facilitated by means of environmental planning instruments (EPIs) and a hierarchy of strategic plans.

The NSW planning system makes provision for three types of planning instruments:

- Strategic planning instruments (i.e., Regional and District Plans),
- Environmental planning instruments (State Environmental Planning Policies and Local Environmental Plans); and
- Development control plans (non-statutory development guidance which supplement EPIs).

In NSW, contaminated land is principally managed under the *Contaminated Land Management Act 1997* (CLM Act), the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *State Environmental Planning Policy (Resilience and Hazards) 2021.* Under section 105 of the CLM Act, the Environmental Protection Authority may make or approve guidelines for purposes connected with the objects of that act. Therefore, there is potential to work with the EPA to develop a PFAS specific guideline to support development of PFAS affected land.

In the case of the SAPs, subregional areas of the State may be nominated as being of particular importance from a planning perspective because of their suitability for new development or urban revitalisation, or because of their social, economic, or environmental characteristics.

With respect to the above, specific planning instruments and policies pertaining to strategic land use and management of PFAS include the following:

- *State Environmental Planning Policy (Precincts-Regional) 2021* (includes SAP provisions and the Master planning, delivery plans and Precinct Certificates to fast track implementation of strategic land use planning).
- *State Environmental Planning Policy (Resilience and Hazards) 2021* (includes provisions for remediation and consideration of contamination when considering appropriate land uses).
- *Central Coast Regional Plan 2041* (includes the Williamtown SAP region, noting this is intended to be superseded by the forthcoming Lower Hunter and Greater Newcastle District Plan prepared by the former Greater Cities Commission, now DPHI).
- *Port Stephens Local Environmental Plan 2013* (provides local land use planning provisions and development standards).

Planning pathways

Development is assessed and approved by the relevant planning authority in accordance with the array of approval pathways established under the EP&A Act. Each pathway contains specific statutory and policy requirements, some of which are contained in Environmental Planning Instruments (EPIs). Relevant to the Review of PFAS in the Williamtown SAP context, these include:

- State Significant Development and Critical and State Significant Infrastructure (Environmental Impact Statement and supporting documentation determined by the planning minister for development deemed to be of state significance).
- Local Development (DA – determined by local councils).
- Complying Development (CDC – codified fast track approval for development that meets defined planning controls).
- Exempt Development (no consent or development application/permit required for minor development).
- Development without consent (i.e., review of environmental factors – self assessment by public authorities).

Different state planning systems would be reviewed and interrogated for potential intervention and streamlining of approval processes pertaining to PFAS affected land as part of our scope, including new PFAS specific guideline for development by Defence in collaboration with the EPA, a site specific LEP/DCP and/or additional permitted land uses in the LEP and /or SEPP in collaboration with Council and the NSW State Government (DPHI).

Flexible land use zoning has been successfully adopted for several precincts in NSW, including the various SAPs, REZs and the Western Sydney Aerotropolis. These include processes which enables the development and articulation of the role of key sites in the short, medium and long term as precincts develop and mature.

The future role and function of some surrounding land in these precincts, including further investigation of certain land uses, is facilitated through interim planning / key site overlays and additional permitted uses in SEPPs that permit development that would otherwise be prohibited under the current zoning (i.e. Luddenham within the Agribusiness zone and Rossmore Precinct in the WSA). This approach enables sustainable transition and allows existing or proposed development as interim uses, whilst minimising land use conflicts and facilitating equitable use of the land.

Challenges for PFAS affected land

The decision by the NSW Government not to proceed with the Williamtown SAP means that land will not be rezoned, therefore current land uses remain unchanged, and landowners are to lodge development applications in accordance with the current planning pathways, which exclude SAP provisions. The land within the Williamtown SAP and surrounds is generally zoned RU2 – Rural Landscape pursuant to the Port Stephens LEP. The current land use zoning limits permissible development that meets objectives of the zone, such as mainlining the rural landscape and primary industry production, extensive agriculture and a variety of tourist and visitor orientated land uses, subject to the consent authority being satisfied that the land is suitable, or can and will be made suitable, for the proposed development.

Therefore, intervention which facilitates an adaptive planning process to provide a default position towards appropriate land use development on PFAS impacted sites that may not fall within an immediate or strategic near-term need is to be investigated with government authorities to enable the equitable development of land.

6 Summary

The establishment of a Social, Economic and Natural Precinct (SENP Precinct) presents a unique opportunity to transform PFAS impacted sites, adding salient and intrinsic value to impacted communities whilst driving regional economic growth, social and natural enhancement. The SENP aims to drive value creation across all levels of development potential, including on (often overlooked) constrained sites. Important to this process is that master planning of communities is founded on clear, value-based principles that seek to build on current master planning and land development accepted best practice. It is acknowledged that there are always constraints to the implementation of a precinct. Typically, this is associated with the prohibitive cost of infrastructure provision, fragmentation of land/ownership as well as the lack of a clearly defined and aligned need and purpose (or value proposition).

This report explores opportunities for potential implementation of a precinct with a particular focus on the Williamtown region as a case study. Significant desktop studies, consultation and evaluation have already been undertaken as part of the Williamtown Special Activation Precinct (SAP) which have formed crucial inputs to this study and provide context to the challenges and opportunities across the potential site. The studies show that the site has numerous constraints, most significantly, flooding, groundwater, poor ground conditions, PFAS impacts and important environmental communities. Counter to this is the strategic nature of the Newcastle Airport and RAAF base, which provide anchor industries and critical logistics infrastructure for the region and wider industrial market. This presents the unique opportunity to leverage Defence and Aerospace industries. However, further to this is, a range of secondary needs and industries that include but are not limited to tourism, natural enhancement, energy transition, freight and logistics, social/community/indigenous facilities, education and recreation.

The SENP seeks to not only consider high value industry needs but also to leverage alternative value add opportunities on less strategic and/or constrained land under a principle of constraint ‘co-existence’, as opposed to avoidance. This report has explored potential opportunities to create these cascading levels of development across a wider area to explore equitable value creation options for PFAS impacted communities holistically.

We have explored the potential to create new development zone/approaches to master planning that enable a regions Unique Value Proposition to be implemented in its entirety whist ensuring that the fundamentals of well master planned communities are preserved. Within each of these zones we expect there are varying levels of opportunity for Government intervention from master planning, planning enablement and investment attraction through to catalyst infrastructure delivery and strategic acquisitions. Equally the approach provides the opportunity for private investment, acknowledging that development on less strategic sites may require market led solutions but providing expedited planning approval pathways, supported by constraint mapping that can act as a catalyst to support emerging industries, entrepreneurial development, and nature enhancement (often through Natural Capital recognition).

A unique element of the SENP approach is understanding that some constraints such as PFAS contamination, evolve over time. This may be through remediation or development of new technologies to safely co-exist/mitigate risks. In such instances it is important that the SENPs are reassessed regularly to ensure the best use of the sites are explored and transitioned to more productive development typologies where appropriate. SENPs have a unique attribute in being a Commonwealth initiative with the potential for flexible benefit realisation timeframes not as easily achievable in State Government settings.

The approach explored has been tested at Williamtown but is universally applicable at other PFAS contaminated sites. The SENP development process seeks to define a unique set of needs (UVP) at any location. The scale of the UVP need is the defining factor for each location which ultimately leads to the resultant physical size of the SENP. Appropriately identifying the UVP is core to the precincts success.

7 Next Steps

We believe the approach explored as part of this report provides a valid opportunity for further detailed investigation and implementation. Acknowledging the limitations of this high-level analysis, we recommend the below next steps:

- Implementation planning of a strategic business case for the development of a SENP pilot study at Williamtown. Leveraging off the extensive work by the NSW Government for the SAP, undertake additional studies, such as additional UVP analysis, revised economic assessments and planning pathway studies to finalise a strategic business case.
- Undertake detailed analysis of the planning approval pathways and State Government support for amendments. The greatest complexity of the approach is the planning approval/governance/legislative framework. Streamlined and flexible zoning is not an unchartered approach. In NSW, it has been explored within the Special Activation Precincts and implemented thought the Activation Precincts SEPP (Regional Enterprise Zoning - REZ as an example). Detailed analysis of how this could be streamlined and adopted across all states and jurisdictions whilst achieving the same strategic objectives is recommended.
- Exploring Williamtown as a detailed case study to refine/hone the strategy with intergovernmental involvement and where appropriate community and stakeholder engagement.
- Seeking opportunities to work with environmental agencies to better streamline PFAS planning and approval pathways as well as co-existence/mitigation guidelines.
- Alignment of the SENP objectives with other evolving governmental initiatives and emerging development standards (such as the Flood Inquiry).
- Development of a multi-level governmental working group.
- Analysis of social licence and community acceptance.

A

Appendix

Reference Documents

Appendix A: Reference Documents

- Williamtown Special Activation Precinct FAQs
- State Environmental Planning Policy (Precincts—Regional) 2021
- Williamtown SAP Draft Masterplan (and supporting studies)
  - Aboriginal Cultural Heritage Report
  - Aeronautical Limitations & Bird Strike Report
  - Discussion Paper - Introduction of Williamtown Special Activation Precinct
  - Bushfire Report
  - Biodiversity Report
  - Air Quality and Odour Report
  - Climate Change Adaption Report
  - Structure Plan
  - Hydrogeology Report
  - Historic Heritage Report
  - Contamination (PFAS and Non-PFAS)
  - Economics Report
  - Geotechnical Report
  - Flooding and Water Cycle Management Report
  - Renewable Energy Report
  - Noise Report
  - Utilities Infrastructure Report
  - Traffic and Transport Report
  - Social Infrastructure Report
  - Sustainability Report
  - Statutory Planning Report
- PFAS Independent Review terms of reference

B

Appendix

Development Principles – Detailed Discussion

Appendix B: Development Principle / SAP Program Differential

The below table outlines the proposed agnostic development principles and highlights the discrepancies between the original Williamtown SAP Program.

Table 1: Development Principle / SAP Program Differentia

	Principle	Purpose / Justification / Goal	Commentary / SAP Program Differentia
What	Community benefit - improving social and economic outcomes for communities impacted by PFAS contamination (including Fist Nations engagement) ■ Defining the unique value proposition of a region ■ evidence based economic projections ■ regional development alignment ■ social equity lens	The primary principle and purpose for the project. It defines its uniqueness as the application of development solutions specifically to PFAS impacted land and the potential to add value to landowners, community & industry through social and economic drivers only available through initial Government intervention. This principle is the primary test point to which all solutions/opportunities must address. A Unique Value Proposition (UVP) for each region must be defined and founded in evidence-based projections. Typically the drivers of growth are categorised into four typologies, namely: ■ Demographic shifts ■ Economic factors ■ Regulatory and policy changes ■ Social, environmental and lifestyle preferences For each region, a UVP will be determined with a focus on opportunities for repurposing PFAS impacted lands. This is not to be limited to traditional 'Highest' value land uses but primarily explore best complementary/compatible use of PFAS lands to meet regional UVP natural or emerging advantages and objectives. Social equity is to be a foundation of this principle's evaluation. PFAS impacts often cover large areas. It is acknowledged that creation of a new regional precinct may favour some sites over others and this is typical in land use planning. Opportunities should be explored to further consider what Social Equity initiatives could be put in place. These could entail: ■ Sharing land value uplift, possibly through a value capture mechanism (or similar). ■ Opportunities to expedite remediation for the region. ■ Government led investment in infrastructure (including social) with regional investment.	The SAP Program sought sites with adjacent or catalytic investments and was primarily driven by the twin objectives of economic development and job creation. Social or community benefits were certainly considered in the SAP Program especially in Moree and Snowy Mountains. However they were generally a secondary consideration. Furthermore, PFAS remediation or treatment was not a consideration in the Williamtown SAP except for risk mitigation as necessary for viable commercial use of the site.

	Principle	Purpose / Justification / Goal	Commentary / SAP Program Differentia
	PFAS Co-existence - allowing communities to thrive and develop in and around PFAS affected areas: ■ remediation activities (e.g. not cost effective to develop). ■ quarantined zones (e.g. strategic long-term land acquisition). ■ development zones (e.g. short-term development potential).	Explore opportunities to streamline Planning Approval pathways process for PFAS impacted land including standardised land management processes for PFAS avoidance and co-existence. Mapping of high risk of exposure/impacted industries/land uses. Develop a guidance framework based on level of contamination, nature of contamination at the site, current land use and future land use options that allow for co-existence. These would be based and built upon existing guidance documents developed by the Heads of EPAs (HEPA), Defence and other relevant international sources. The project should explore opportunities to assess and designate regions of the precincts where development of PFAS land is economically viable and practical to do so without causing adverse impacts to neighbouring communities/region or the environment. This will provide clarity to landowners/investors where development may be: ■ Viable with no mitigation measures needed. ■ Viable with little mitigation measures. ■ Viable with significant mitigation measures. ■ Long term viability following remediation (these may potentially be sites with where levels of PFAS exposure are high or their development may cause mobilisation of PFAS) ■ It is equally important that any future development does not preclude remediation activities.	The SAP program understood the importance of streamlined planning approvals to encourage investment, and this has enabled cornerstone investors in Parkes. Wagga Wagga and Moree to quickly firm up the business case for those SAPs. The Williamtown SAP developed an Adaptive Planning framework for PFAS that allowed for clear guidance on the mitigation measures required at a site based on nature and level of contamination when construction details were better known. This approach allowed for site specific approaches to be adopted and also acknowledges the changing nature of contamination across sites over time as remediation works improve impacts on land.

	Principle	Purpose / Justification / Goal	Commentary / SAP Program Differentia
	Defence capability enhancement - align needs to adjacent Defence bases and their projected strategic needs (short/long term) ■ invest to unlock further precinct development. ■ investment attraction activities to stimulate demand.	In parallel to principle 1, PFAS impacted communities adjacent to Defence establishments provide a unique opportunity for Defence to facilitate a number of growth initiatives for the local region and economy. Where permissible opportunities should be explored by Defence in the following areas: ■ Re-evaluating programmatic and sustainment initiatives that could be delivered off Commonwealth land in the public domain (on PFAS impacted sites), potentially holistically by the private sector. This could include defence adjacency needs such as key worker housing, social services, defence industry (primes). ■ Re-evaluating wider Defence programs for their applicability to the region, specifically when viewed with addressing PFAS impacted lands. ■ Exploring opportunities for Defence to stimulate growth of supporting adjacencies and/or opportunities to remove barriers to growth through catalytic investment (Opportunities for Defence to invest in infrastructure to unlock development or acquisition of strategic lands) ■ Opportunities for Defence to undertake investment attraction activities to stimulate growth in the regions.	The Williamtown SAP clearly identified the Defence and Aerospace industries as the best economic cases for value uplift of the site. The principles; established in this document, goes a step further in allowing a more deliberate and direct consideration of Dept. of Defence strategic needs over a longer time frame, not just Defence industry adjacencies. The result could be establishing strategic land holdings beyond existing boundaries, moving existing Defence sustainment contractors off-base (e.g. Boeing at RAAF Williamtown) or unlocking land for strategic investment (e.g. Taxiway G adjoining Astra Aerolab at Williamtown).

	Principle	Purpose / Justification / Goal	Commentary / SAP Program Differentia
	Governmental and Private sector initiatives and programs to support social and economic growth ■ Government programs. ■ Private sector led opportunities. ■ Natural advantages. ■ Community Enhancement Initiatives.	Explore economic and social needs of the region to determine catalytic industries that could act as a pillar for growth and change. The following opportunities could be explored: ■ Regional demands for supply based on current needs across all sectors relevant to a region. ■ Review of current government and private sector major initiatives and catalytic programs in the regions (Examples include Renewable Energy Zones, Inland Rail, Supply chain efficiencies, Primary Industry needs). ■ Review of emerging trends and government strategies. ■ Review of social and community needs, including Indigenous engagement ■ Review of environmental needs and requirements for the region. Understanding ecosystem and biodiversity needs of the region.	This approach is contrasting to the SAP approach that sought to find precincts that aligned to government projects and regional initiatives. A long list of potential SAP sites underwent a rigorous evaluation process and programmatic business case to determine which locations had the greatest alignment to their principles and purpose (primarily job creation). In the case of a Social, Economic & Natural Precinct impacted by PFAS, we are alternatively aiming to explore options for supporting renewal and growth in regions/areas/precincts that are already predetermined by PFAS presence. The options to support growth are therefore more location specific and tailored to the regions primary industries, market demands and social drivers.

	Principle	Purpose / Justification / Goal	Commentary / SAP Program Differentia
How	Master planning of Precincts - ensure a precinct approach is taken to development prevent uncoordinated projects include dynamic uses over time: - simplify planning and development pathways for PFAS affected land. -rezoning / flexible zoning. Potentially restricting some land uses in some areas.	Government led/sponsored studies and co-ordinated master planning. The Government will sponsor and lead master planning studies based on the founding 'what' principles that support the development of a Social, Economic & Natural Precinct across PFAS impacted communities. Centrally co-ordinated master planning helps ensure the precinct USP is maximised and builds agglomeration benefits unachievable in an open development. Government will seek opportunities to explore streamlined development pathways and development of a simplified PFAS delivery strategy. Explore opportunities to facilitate flexible rezoning processes to allow long term development adaptation as PFAS impacts change and market factors evolve (i.e. long-term Defence Programs) Master planning studies will identify constraints and opportunities across the study areas and in parallel with market analysis will determine optimum options for short-, medium- and long-term horizons. The masterplans will identify 'market failures' and opportunities for intervention through Government and private sector intervention. Opportunity to explore flexible rezonings in fringe lands to enable certain (but limited) types of development to occur through a streamlined process, noting that these lands may not be required to strategically meet market needs (and may not be optimally located) but could support social and /or environmental projects (Such as biodiversity offsetting).	It is recommended that Government undertake a holistic master planning process for the PFAS impacted communities. The Special Activation Precinct Process provides a proven framework for assessment of masterplans and community needs holistically and is undertaken agnostic of land ownership but consulted with the community through traditional exhibition phases.

	Principle	Purpose / Justification / Goal	Commentary / SAP Program Differentia
	Long-term strategic pathways - allow staged investments that consider Defence and community needs (not necessarily highest and best use).	Develop staged rezoning and delivery plans that consider both long term growth and demand over time but allow for flexible land use changes over time providing opportunities for near term value creation with options for longer term alterations and demand grows. It acknowledges that some sites may not be suitable or required for their highest and best use form the onset but allows for interim development to occur creating value for landowners.	This approach would be unique to a Social, Economic & Natural Precinct. Often master planned developments consider a binary land use change, usually to the highest value development option. This is also traditionally balanced by staging land release so as not to oversaturate the market. This serves to control development and focus investment spend which are positive outcomes. However, this focussing of development may leave certain sub-areas stagnate until such time as demand justifies their rezoning. Opportunities could be sought to provide interim flexible zoning in non-prioritised areas allowing near-term developments such as social and environmental opportunities that provide a near term benefit to the community and minimal burden on infrastructure needs. Longer-term as the need arises for more productive use of the land, these developments could be activated/transition to higher uses. Ultimately this approach provides some near-term social equity allowing some land value uplift whist not creating inefficient development fronts or rezoning too far ahead of demand.

	Principle	Purpose / Justification / Goal	Commentary / SAP Program Differentia
	Align to broader Govt (3 layers) policy and initiatives.	Explore opportunities for Intergovernmental coordination and collaboration with Commonwealth/State led and funded investigations, master planning and statutory planning. ■ **Commonwealth/Defence:** Project Sponsor, Defence led Investment Attraction, PFAS Expedited Planning and Design Guidelines, Potential for Catalytic Investment to enable development, business case for federal initiatives (supported by delivery strategy). ■ **State Government:** Planning Framework and Statutory Amendments (as required), Master planning, Delivery Strategy and Investment Attraction, business case for state initiatives (supported by delivery strategy and incorporating Commonwealth initiatives). ■ **Local Government:** Investment attraction, local planning amendments/instruments, proponent in master planning. Explore opportunities for the masterplans to support broader non-region-specific Governmental Initiatives such as Net Zero, Resilience, Decarbonisation etc and to support/promote opportunities for First Nations Peoples.	A coordinated Governance Framework is critical to the success of the precincts. It is important to acknowledge the traditional roles each level of Government is best suited to support/lead. In the instance of a Social, Economic & Natural Precinct relating to PFAS it is important for the Commonwealth Government/Defence to act as the Project Lead/Sponsor, as sites are agnostic of State Jurisdiction, it will be critical to have common principles and objectives across a program of sites. It is best placed for State Government to lead planning policy amendments given their uniqueness. It will be important that the outcomes and purpose are echoed at a state level to ensure equitable consistency.
	Explore Government and Private sector delivery and funding opportunities: ■ Funding and finance. ■ Investor attraction.	Develop delivery plans and strategies for activation and implementation. Traditional approaches include: ■ **Organic Private Sector Growth:** Rezoning and expedited planning pathways, no other Government intervention. ■ Government Led Investment Attraction and Contribution Schemes: ■ Government Led Investment in Catalyst Infrastructure/Development and Strategic Acquisition (as required). ■ Government and Private Sector Led Development (PPP's etc). The above would be evaluated and supported through the traditional business case process.	

C

Appendix

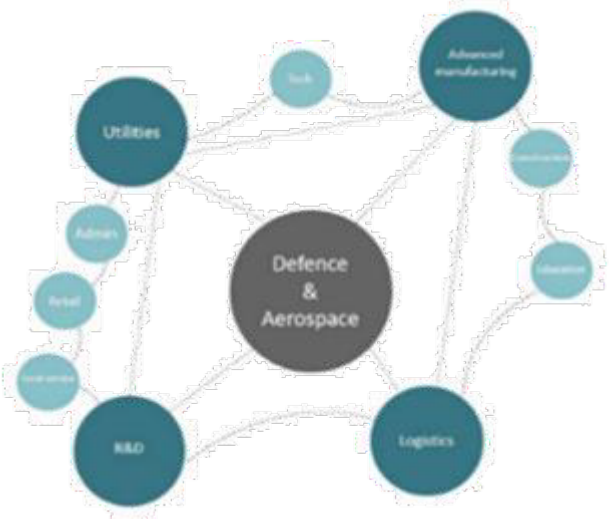
Application of Development Principles to Williamtown

Appendix C: Application of Development Principles to Williamtown

The following sections outline how the S&EP principles could be applied to Williamtown to yield a different land use typology and opportunities for PFAS impacted sites. The vast technical studies prepared for the Williamtown SAP have been utilised to inform advice and decisions made around developability of sites. The below would need subsequent master planning and testing to ensure economic viability.

Table 2: Application of Development Principles to Williamtown

	Principle	Possible Application to Williamtown	Commentary
What	Community benefit - Improving social and economic outcomes for communities impacted by PFAS contamination (including First Nations) ■ Defining the unique value proposition of a region ■ Evidence based economic projections ■ Regional development alignment ■ Social equity lens	**Williamtown:** Unique Value Proposition (UVP): ■ Job creating propositions: – Defence adjacency. – Aerospace Industry (Manufacturing, logistics). – NAPL Expansion and runway expansion. – Gateway for High Value Freight and Logistics. – Hunter Transition (Mining (Sand/Coal) to Energy and Manufacturing) – Educational needs. ■ Other propositions: – Housing Shortages. – Water Resource Abundance (Sea and Freshwater). – Thriving Indigenous Prescence and Cultural Opportunities. – Tourism Gateway and Opportunities (also tied to First Nations Considerations). – Sensitive Environment and established TEC's. – PFAS Treatment. – Energy Transition Initiatives. – Mining Adjacencies.	Job creating propositions address SAP Principles and have been somewhat explored by the Williamtown SAP. The Social, Economic & Natural Precinct will also explore options for interim uses of land listed in the other propositions. These could be transitional uses or programs.

	Principle	Possible Application to Williamtown	Commentary
		 ***Williamtown SAP Economic Report Focus Industries (by others)***	
	PFAS Co-existence - allowing communities to thrive and develop in and around PFAS affected areas: ■ remediation activities (e.g. not cost effective to develop). ■ quarantined zones (e.g. strategic long-term land acquisition). ■ development zones (e.g. short-term development potential).	Development of PFAS Adaptive Planning Pathways and Design Guidelines for Management of PFAS. Supplementary uses for land with higher risk for PFAS exposure which are relatively more costly to develop due to other environmental constraints such as flooding and poor ground conditions. Longer term, whilst trivial, considerations could be made for future developments that are fully Automated and remove human exposure to PFAS and other site risks. The technical documents developed during the SAP master planning process included a number of potential mitigation measures that could be employed that are not active remediation. The overall objectives of these mitigation measures were removal of exposure pathways to PFAS impacted soil and water and removal of any incidental PFAS in stormwater. While some options were prohibitively expensive, or logistical not feasible at the precinct level, they could be applied at smaller scales. The fill material required for development in the SAP area would provide sufficient separation between any potential receptors. Liners, such as geosynthetic clay liners, could be used to separate clean material from PFAS impacted material. Constructed wetlands and bioretention basins could be constructed to treat stormwater, remove PFAS and provide amenity.	

	Principle	Possible Application to Williamtown	Commentary
	Defence capability enhancement - align needs to adjacent Defence bases and their projected strategic needs (short/long term): ■ invest to unlock further precinct development. ■ investment attraction activities to stimulate demand.	■ Shifting defence contractors off base. ■ Expansion of specific Defence programs – F35, Space and attraction for Defence Primes. ■ Unlocking development stalling at Astra Aerolab (Taxiway G). ■ Relocating Fighter World. ■ Catalytic investment in Taxiway upgrades/Enabling utilities infrastructure. ■ Defence Related Education needs and collaboration with Educational Establishments (Universities/TAFE etc). ■ Explore Opportunities for wider (unknown) Defence programs both Short and Long Term, where Williamtown may be a suitable candidate.	
	Governmental and Private sector initiatives and programs to support social and economic growth: ■ Government programs. ■ Private sector led opportunities. ■ Natural advantages. ■ Community Enhancement Initiatives.	■ Net Zero initiatives and the energy transition. ■ Renewable Energy Zones Supporting industries and supply chain (Gateway for CWO & HCC REZ 's). ■ Skilled workforce transition out of Mining Industries. ■ Addressing ongoing flooding and climate change issues at Williamtown – Port Stephens Council. ■ Collaboration with eager local private developers. ■ Collaboration with Newcastle Airport (Astra Aerolab development). ■ Cultural and Indigenous uses. ■	

How	Master planning of Precincts - ensure a precinct approach is taken to development prevent uncoordinated projects include dynamic uses over time: - simplify planning and development pathways for PFAS affected land. - rezoning / flexible zoning.	The master planning process for Williamtown involved a comprehensive suite of technical studies. It was built based upon detailed analysis of the unique offerings associated with the site, region and its ability to support economic growth and jobs creation. In parallel, a suite of site constraints and development suitability studies were undertaken to better understand areas of the site where: 1.1.1 development was not possible/practical (No go zones), 1.1.2 areas where development was permissible with some level of intervention/mitigation works to offset impacts and 1.1.3 lastly areas of the site that were free of any major constraints. Objectively, the SAP was master planned based on three main characteristics, ■ Availability of suitable land to meet market demand needs in relation to land uses that complement the SAP's vision. In this instance, the Defence and Aerospace sectors were primarily targeted, and adjacent industries considered (such as freight, logistics, commercial and Education). ■ Strategic proximity to the airport and surrounding transport networks. ■ Constraints avoidance and/or co-existence (with assessment of mitigation measures). ■ Section 2 outlines some of the challenges associated with developing the proposed land uses in the SAP assessment. The primary land use for the precinct was typically characterised as a large scale industrial/logistics precinct. When considering the constraints across the site, developing a resilient precinct of this nature brought with it significant engineering interventions to address predominantly flooding but also PFAS avoidance and poor ground conditions. This is likely to have contributed to the CAPEX challenges with development, ultimately rendering the SAP strategy unfeasible. It should be noted that the SAP planning process considered co-existence and avoidance of PFAS, but excluded remediation which was to be managed by Defence. The Adaptive Management approach to PFAS explored as part of the SAP lays strong foundations for adoption of a similar approach for PFAS co-existence, governance and streamlined approvals. ■ When reevaluating the strategic studies against the Principles of a **Social, Economic & Natural Precinct** two key themes are reconsidered: – In locations where it is economically viable to do so, could the Precinct <u>partially</u> contribute to supporting the overall strategic high value needs identified as part of the SAP (Defence and Aerospace Industries)? Also considering PFAS impacted Lands. – In residual (typically adjacent) PFAS impacted lands, including PFAS land that is also constrained by other factors such as flooding, could alternative uses be explored that	

creates a value uplift for the land and addresses a regional need? Noting that the perceived highest and best use of the sites may not be the most economically viable.

- The above then allows for a more complex multifaceted ecosystem of development opportunities to occur. It is however noted that well master planned communities/developments have a level of coherence and complementarity. This needs to be equally considered when exploring alternative land use options for constrained land. In doing so we recast the notion that 'highest and best use' is intrinsically associated with the perceived hierarchy of land zoning options (i.e. High Density Residential > Low Density Residential) and in heavily constrained locations Best Use may in fact be a softer level of development or land use change.

When reconsidering the above the following considerations could be explored:

- Priority Defence and Aerospace related Locations:
  - Prioritisation of the Astra Aerolab development (primarily supported by a new Taxiway). A key to unlocking the Defence and Aerospace adjacent industries is providing development proximity to the Airport as well as Airside access (which is currently quite limited). The Taxiway extension earmarked in the SAP provides this catalyst infrastructure. Whilst the Astra site is not free of development constraints, it is less flood encumbered than areas north of Cabbage Tree Road and provides proximity to the Airport.
  - In addition to the above the "Freight and Logistics" (as identified in the SAP masterplan) remains the second most viable options for Defence and Aerospace related development opportunities. There is potential that the cumulative impacts for the Astran and Freight and Logistics precincts may have a cumulative impact on Flooding and this would need to be addressed locally (that may mean a reduction in development footprint in these locations.
- Adjacent PFAS & Constrained Land:
  - Whilst many facets and strategies of the SAP master planning could be maintained in the above locations, it is noted that the most heavily constrained portions of the site are North of Cabbage Tree Road. Widespread flooding, groundwater, environmental communities, sea level rise, poor ground conditions and PFAS dominate the constraints. It is likely that these constraints along with land fragmentation have prohibited development from occurring in the past. The SAP masterplan explored ways of managing these challenges at a precinct level but appear to have resulted in an uneconomical outcome. Noting this and that the purpose of a Social, Economic & Natural Precinct is to explore alternative compatible land uses to drive land activation of PFAS land, there is merit in exploring complementary and compatible land uses

	Principle	Possible Application to Williamtown	Commentary
		that also contribute to the wider social, environmental and economics of the wider community. – In these locations this could include such developments as (but not limited to): - Nature based tourism & Eco-tourism. - Cultural and Indigenous uses. - Environmental Protection/Preservation. - Biodiversity Offsets Schemes (BOS) under the *Biodiversity Conservation Act 2016* (BC Act). - Energy Transition Initiatives. - Utilities Infrastructure (Possibly Geothermal heating/cooling). - Floating and Modular Developments. - Multipurposed open space areas such as *Buitenschot Land Art Park* as noted in the SAP masterplan that provides noise attenuation through effective land management. - PFAS management/treatment sites. – The above are examples of development that present opportunities for compatibility with the site constraints but in some instances would require some level of rezoning to occur to permit these types of developments. Furthermore, these developments are likely to have a commercial return on investment and this pathway provides an option for value creation through Government intervention (master planning/rezoning). The best way to implement such a system would need to be explored. The implementation would have to be tailored to varying constraints; not all sites are equally constrained and therefore more development options could be considered. However, the SAP's developed a similar framework for the "Regional Enterprise" zoning as part of the Activation Precincts SEPP that was created to allow controlled flexibility of development. ■ 	

	Principle	Possible Application to Williamtown	Commentary
	Long-term strategic pathways - allow staged investments that consider Defence and community needs (not highest and best use).	Develop staged rezoning and delivery plans that consider both long term growth and demand over time but allow for flexible land use changes over time providing opportunities for near term value creation with options for longer term alterations and demand grows. It acknowledges that some sites may not be suitable or required for their highest and best use form the onset but allows for interim development to occur creating value for landowners.	This remains the same objective as the development Principles
	Align to broader Govt (3 layers) policy and initiatives.	Explore opportunities for Intergovernmental coordination and collaboration with Commonwealth/State led and funded investigations, master planning and statutory planning. ▪ **Commonwealth/Defence:** Project Sponsor, Defence led Investment Attraction, PFAS Expedited Planning and Design Guidelines, Potential for Catalytic Investment to enable development, business case for federal initiatives (supported by delivery strategy) ▪ **State Government:** Planning Framework and Statutory Amendments (as required), Master planning, Delivery Strategy and Investment Attraction, business case for state initiatives (supported by delivery strategy and incorporating Commonwealth initiatives) ▪ **Local Government:** Investment attraction, local planning amendments/instruments, proponent in master planning. Explore opportunities for the masterplans to support broader non-region-specific Governmental Initiatives such as Net Zero, Resilience, Decarbonisation etc and to support/promote opportunities for First Nations Peoples. Establishment of an ongoing review mechanism as PFAS and regional needs change will be important. This is likely to be best led by the Commonwealth Government and/or Defence at a programmatic level and market attractors for the regions.	This remains the same objective as the development Principles

	Principle	Possible Application to Williamtown	Commentary
	Explore Government and Private sector delivery and funding opportunities: ■ Funding and finance. ■ Investor attraction.	Opportunities: ■ Acquisition opportunities to amalgamate sites to achieve more coherent development outcomes and to implement precinct scale initiatives. ■ Government forward funding of catalyst/enabling infrastructure. – This could include the Taxiway, relocation of existing developments to unlock land, utilities (shared with agencies) and transport infrastructure upgrades. ■ Development of value capture and/or contributions schemes. ■ Developing an infrastructure delivery plan allowing developers to enter into Works-in-Kind agreements for enabling infrastructure. ■ Government/Defence Led Investment Attraction. ■ It will be important to establish appropriate mechanisms that enable the long-term self-sustainment of the precinct and to fund ongoing infrastructure upgrades so that development does not stagnate in the future.	

D

Appendix

Application of SENP Principle to Oakey and Tindal

Appendix D: Possible Application of the SENP Principle to Oakey and Tindal

As discussed in the body of the report the key initial study when considering a new SENP is to define a Unique Value Proposition for a region/community. This dictates the underlying short and long term needs to support land use changes and growth. This is a precursor to master planning but validates the potential for a 'need' to be explored.

We have explored at a very high level some potential Oakey and Tindal UVP opportunities These suggest there is justification for further investigation and bespoke application of the SENP process/principles to these sites. Further detailed assessment is required to explore the UVP and understand the associated scale of market needs (number of resultant Jobs, housing, etc). In addition, what is unknown at this stage, is the opportunity for Defence capability enhancement. Like Williamtown, this enhancement potential is unique to Defence adjacent communities like Oakey and Tindal. This may include programs of work/initiatives that are not publicly available but where the long term needs of Defence could support additional growth/activation.

Complementing the UVP, additional detailed assessments are needed to explore the sites' context and constraints which will allow spatial assessment and master planning of the UVP to occur. It recommended that these studies be undertaken as a next step.

E

Appendix

Principles of Land Use Planning and Precinct Development

Appendix E: Principles of Land Use Planning and Precinct Development

When considering opportunities for development change and/or intensification as a catalyst for growth, we often require a key driver supporting the need for change. These drivers may be leading or latent. For example, in NSW as of 2023 there is significant demand for new housing supply, this is seen as a leading driver with the resultant demand being new housing supply. Similarly, when new housing in areas is constructed, this will then lead to increased population and then there may be additional needs for social infrastructure and such, which in this instance would be a latent driver as a result of new housing and population growth in an area.

This basic supply and demand; based around a key driver, ultimately underpins successful urban developments and is an important factor to consider when exploring opportunities for new precinct development. Historically the lack of a driver or an overestimation for a driver can lead to poor land development uptake and an inability to realise development.

Several factors can underpin market demand for land development change and/or intensification, influencing the decisions of developers, investors, and ultimately, residents and businesses. Here are some key drivers:

Demographic shifts

- **Population growth**: Rising population puts pressure on existing infrastructure and housing, potentially increasing demand for denser development or expansion into new areas.
- **Changing age demographics**: An aging population might require more senior living options and healthcare facilities, while a young population might favour walkable, mixed-use communities.
- **Urbanization trends**: Migration towards cities fuels demand for urban housing, offices, and amenities, leading to potential intensification in existing urban areas.

Economic factors

- **Job growth**: Strong economic activity and job creation in specific sectors can drive demand for housing and commercial space near employment centres, potentially leading to intensification or development in surrounding areas.
- **Interest rates and investment climate**: Low interest rates and a favourable investment climate can encourage investment in land development projects, particularly those offering attractive returns.
- **Emerging industries and technologies**: The rise of new industries or technologies can create demand for specialized infrastructure or development types, shaping land use patterns.

Regulatory and policy changes

- **Government policies**: Zoning regulations, land use plans, and infrastructure investments by the government can influence development patterns and incentivize certain types of development (e.g., transit-oriented development, mixed-use projects).
- **Tax breaks and incentives**: Government incentives like tax breaks or financial subsidies can attract developers and investors to specific areas or development types, driving demand for change or intensification.
- **Environmental regulations**: Environmental regulations can incentivize development that is energy-efficient, sustainable, and minimizes environmental impact, potentially influencing demand for green building practices and retrofitting existing buildings.

Social and lifestyle preferences

- Demand for walkable and vibrant communities: Residents increasingly seek walkable, mixed-use communities with easy access to amenities and public transportation, potentially driving demand for intensification in existing urban areas.
- Desire for green spaces and sustainability: Growing environmental consciousness can lead to demand for developments that incorporate green spaces, sustainable practices, and energy efficiency.
- Changing housing preferences: Preferences for smaller living spaces, co-living arrangements, and home-sharing platforms can influence the type and density of development demanded.

It's important to note that these factors often interact and influence each other. For example, population growth combined with favourable government policies and economic conditions can create a strong market demand for land development change or intensification in specific areas.

Understanding the specific factors influencing market demand in a particular location is crucial for developers, investors, and policymakers to make informed decisions about land use planning and development strategies.

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