Document 5

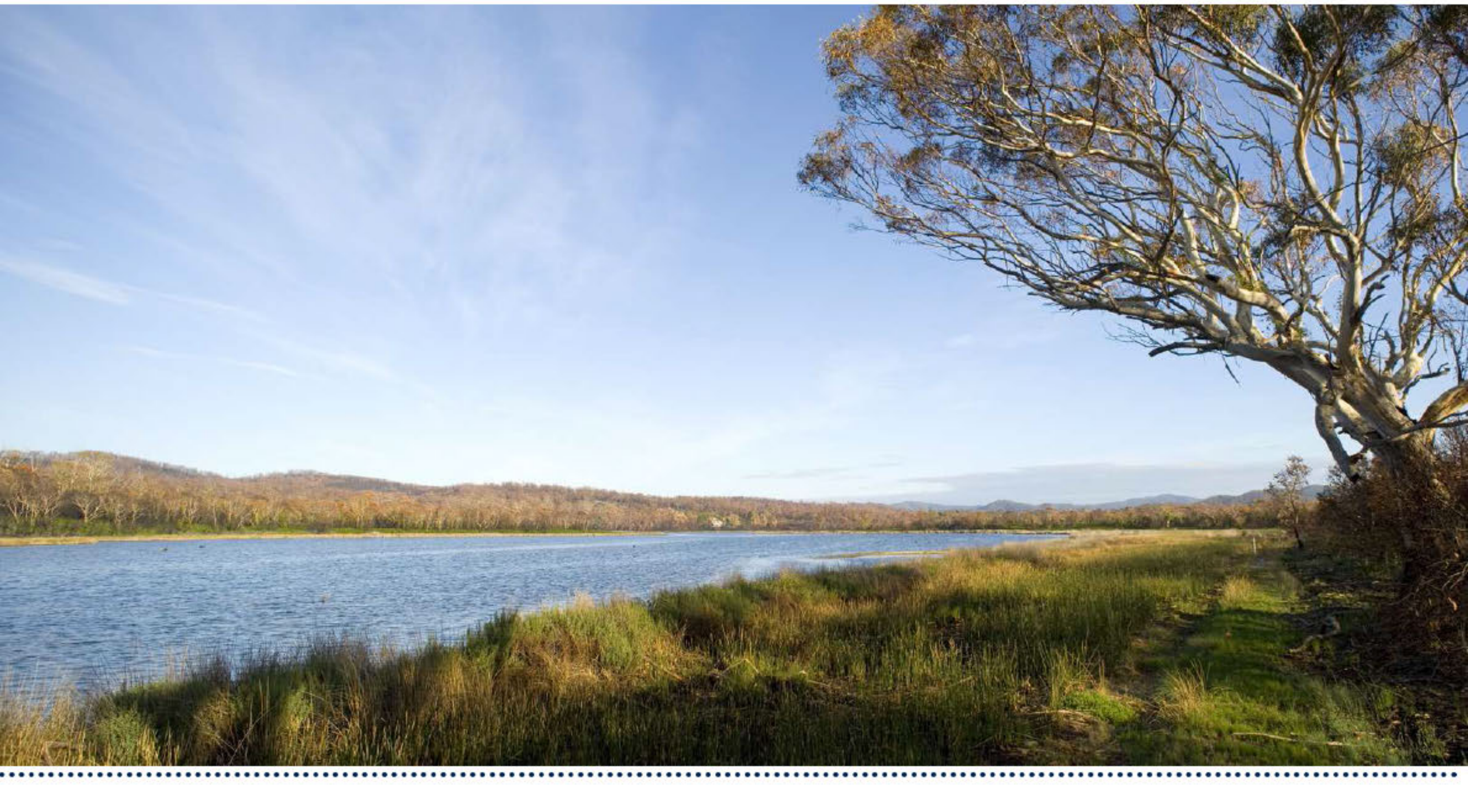
Australian Government
Department of the Environment and Energy

National phase out of PFOS

Ratification of the Stockholm Convention amendment on PFOS

Regulation Impact Statement for consultation

October 2017



EXECUTIVE SUMMARY

Introduction

This Regulation Impact Statement (RIS) was prepared by the Australian Government Department of the Environment and Energy on behalf of the Government. It presents options for the regulation of perfluorooctane sulfonate-related chemicals (PFOS) to protect the environment and human health.[1]

The proposed national regulation of PFOS would establish an integrated approach to management throughout the life cycle of these chemicals, reducing the burden on industry from inconsistent regulation of PFOS across jurisdictions and from the possibility of interruptions to the import of essential PFOS-containing products such as X-ray films. It would support strategies in each jurisdiction to manage and regulate PFOS, consistent with Australia's established approach to chemicals management as a partnership between the Commonwealth and state and territory governments. It would lead to significant reductions in PFOS releases to the environment and the commensurate risks to environmental health and potentially to humans.

National regulation would also be required to give effect to Australia's obligations arising from the 2009 amendment listing PFOS under the Stockholm Convention on Persistent Organic Pollutants (the Stockholm Convention), should Australia decide to ratify this amendment.[2] The Stockholm listing reflects a decade of in-depth assessment of PFOS through the United Nations Environment Programme (UNEP) and the Organisation for Economic Cooperation and Development (OECD). Currently 171 countries have ratified the Stockholm Convention listing of PFOS, including 30 OECD countries such as the United Kingdom, Germany, Japan, Korea and New Zealand. The main global PFOS supplier, China, has also recently ratified the listing. The United States began phasing out the production of PFOS in 2000, with exemptions for special uses. As such, the proposed regulation is consistent with the Government's principle of adopting trusted international standards and risk assessments.

The options presented seek to minimise future exposure of humans and the environment to PFOS, by aligning the management of PFOS in Australia with the globally-accepted standards established by the listing of PFOS under the Stockholm Convention. This integrated approach would reduce the burden on industry from varying requirements across jurisdictions and from the possibility of interruptions to PFOS-containing imports.

The summary on the next page outlines the key issues addressed in this RIS. Relevant sections of the RIS itself provide more detailed analysis of the problem, why action is needed, Australia's options for action, and the impacts of the options.

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[1] As explained in Section 2.1, the scope of this RIS comprises the PFOS-related chemicals listed in Annex B of the Stockholm Convention. Annex B lists perfluorooctane sulfonic acid, its salts, and perfluorooctane sulfonyl fluoride (PFOSF). The listing of PFOSF also covers the broader range of PFOS-related chemicals that are produced from PFOSF (see *Attachment A* for a list of the PFOS-related chemicals that are listed in the Australian Inventory of Chemical Substances). The OECD Environment Directorate (2007) maintains a comprehensive list of known PFOS-related chemicals, including those thought not to have been used in Australia. These PFOS-related chemicals are part of a larger family of synthetic fluorinated chemicals known as per- and poly-fluoroalkyl substances (PFASs).
[2] For information on the Stockholm Convention, see Section 1, Box 1, and Box 11.

National phase out of PFOS
Regulation Impact Statement summary

Problem

The ongoing release of perfluorooctane sulfonate-related chemicals (PFOS) into the Australian environment exposes humans and the environment to contamination with externality costs to communities, businesses, governments and the environment around Australia. Government action is needed to ensure sound management meeting the internationally accepted standards established by the Stockholm Convention listing of PFOS. Action now will limit future PFOS exposure and reduce possible future contamination. Ratification of the Stockholm Convention listing would also secure the ongoing supply of PFOS imports for essential uses.

Recommended option

Subject to consultation findings, the analysis suggests that ratification of the Stockholm Convention listing of PFOS and banning of all non-essential uses of PFOS would deliver the greatest net benefit to Australia.

Objectives

To protect the environment and human health from the potential impacts of PFOS by minimising emissions with flow on benefits to society, the economy and the environment.

Options considered

Two options consistent with the management standards established under the amendment to the Stockholm Convention, should the Australian Government decide to ratify the amendment, along with an option for light touch regulation of PFOS and the base case of no regulation.

Impacts of regulatory options

All options other than the base case would provide national consistency, improve protection of the environment and human health and ensure import security for industry during the phase out of PFOS. Option 4 achieves the greatest reduction in emissions at the lowest cost.

Benefits and costs

The least cost option would cost around $39 million over 20 years. The benefits are unquantifiable but significant and avoid potential risks. It is noted that Health authorities in Australia are recommending that people reduce and minimise exposure as a precaution.

Consultation approach

Analysis to date has included extensive consultation with industry and Australian governments to develop and inform options. Broad public consultation will occur over two months on the proposed options and include targeted consultation with affected communities, industries, state and territory governments, and Australian Government departments and agencies.

Stakeholder views

Stakeholders and the community are expected to welcome certainty on Australian Government action to control PFOS. Senate enquiries on fire fighting foams have called on the Government to prevent the chemical being used. Some industry stakeholders may be concerned about the costs and the perceived effectiveness of PFOS alternatives.

The problem

The synthetic PFOS-related chemicals were used for a wide variety of applications during the twentieth and early twenty-first centuries. In Australia, the main industries currently using PFOS-related chemicals include hard chromium plating, decorative chromium plating (including plastics etching), medical imaging (including X-ray photography and some older medical imaging devices), and fire fighting.[3]

Industry has phased out most non-essential uses of PFOS following the recognition of risks to the environment and potential risks to human health. Although the evidence on PFOS risks is still evolving, studies in animals have shown reproductive, developmental and systemic effects.[4] It is not currently possible to estimate a safe level of PFOS. Substances that are very persistent and bioaccumulative, like PFOS, have the potential to accumulate in the environment with long-term effects that are unpredictable and difficult to reverse even when emissions cease. In light of the known and potential risks of PFOS, the aim of regulation should therefore be to minimise any releases to the environment as far as possible.

Recent experiences demonstrate the burden of externality costs from PFOS contamination for Australian governments, communities and businesses. In 2016, the Government committed $55.0 million to address issues linked to contamination by PFOS and related chemicals at Defence sites. Other costs are being borne by state, territory and local governments, businesses and individuals. The greatest impacts in areas contaminated with PFOS are on residents using groundwater and by small businesses, particularly in the fishing industry.

Why is Government action needed?

The need for Government action reflects market and regulatory failure in relation to the problems described above. The key elements of market failure in relation to PFOS include:

- an information deficit regarding the negative externalities associated with PFOS use
- the reluctance of some PFOS producers and users to mitigate these negative externalities even where information is available
- the inability of governments to ensure these negative externalities are captured in the pricing of PFOS-related chemicals.

There is currently no nationally consistent legislation that can ban or restrict the use of an industrial chemical. If a decision were made to ratify the listing of PFOS under the Stockholm Convention, governments would need to put in place new controls to phase down or phase out ongoing PFOS uses and prevent uptake of PFOS use by other industries.

Options for action

This RIS presents three options for government action, as well as the base case of no new government action, with the following estimated financial costs to government and industry over 20 years. There are no costs identified for individuals or community groups. Importantly, the proposed options focus on limiting future PFOS emissions and as such will not address historical issues such as previous emissions or currently contaminated sites. These options,

[3] These industries are profiled in more detail in *Attachment G*.
[4] See Table 4 for an overview of research on the impacts of PFOS on animals.

the measures under each option, and the transition arrangements will be reviewed in light of the feedback provided by stakeholders during consultation on this RIS.

Summary of the options for phasing out PFOS

Option	Summary
Option 1: No new policy intervention	Uncosted baseline. Australia would not take any new actions to phase out PFOS use or reduce emissions.
Option 2: Do not ratify, but implement certification requirements	Estimated cost: $100.80 million. Australia would implement controls on PFOS emissions and waste disposal to meet the Stockholm Convention certification standards.[5] This would allow the Government to provide certification for PFOS to countries that have ratified the Stockholm Convention listing of PFOS, so that PFOS imports from these countries can continue. This option would reduce PFOS emissions as a result of strengthened management practices but would not prevent the risk of accidental releases. Subject to consultation, this change could be implemented through amendments to existing legislation and policy. Aside from improved waste management, no restrictions would apply to current PFOS uses and Australia would not ratify the Stockholm convention listing of PFOS.

[5] The Stockholm Convention sets out the certification requirements in Article 3(b)(iii), including committing to protect human health and the environment by minimising or preventing releases and complying with waste disposal requirements set out in Article 6.1.

Option 3: Ratify and register permitted uses	Estimated cost: $100.53 million. In addition to implementing the PFOS waste disposal controls outlined in Option 2, Australia would implement controls on PFOS import, export, manufacture and use to meet Stockholm Convention standards.[6] Australia would ratify the Stockholm Convention listing of PFOS and register for the continued use of PFOS for fire fighting, hard chromium plating, photo-imaging (X-ray photography) and certain medical devices (CCD colour filters) and for a five-year phase out of decorative chromium plating and plastics etching.[7] This option would reduce PFOS emissions as a result of strengthened management practices but would not prevent the risk of accidental releases. Subject to consultation, these changes could be implemented through new legislation or amendments to existing legislation and policy.
Option 4: Ratify and phase out all non-essential uses	Estimated cost: $38.75 million. In addition to implementing the PFOS controls outlined in Option 3 to meet Stockholm Convention standards, Australia would ratify the Stockholm Convention listing of PFOS and register for the continued use of PFOS for photo-imaging (X-ray photography) and certain medical devices (CCD colour filters). All other uses of PFOS would be banned. This option would effectively prevent the ongoing risk of accidental releases of PFOS by requiring its withdrawal from use. Subject to consultation, these changes would be implemented through new legislation or amendments to existing legislation and policy.

Impact analysis

A national approach to regulation of PFOS would provide assurance to the community, industry and all levels of government that Australia is taking comprehensive action to minimise potential risks and costs from future PFOS emissions. It would support and strengthen the action being taken in this regard by state and territory governments, as well as internationally, to protect the environment, human health and communities from PFOS contamination.

[6] Articles 3, 4, 5 and 6 of the Stockholm Convention set out the key requirements for implementation.
[7] The continued uses proposed for Option 3 are broadly consistent with the uses already registered by several other OECD countries, noting that for the hard chromium plating industry continued PFOS use would be allowed only in closed loop systems. For details see http://chm.pops.int/Implementation/Exemptions/AcceptablePurposesPFOSandPFOSF/tabid/794/Default.aspx

New regulation will be required to implement Options 2 to 4. This could be progressed through significant amendments to existing state and territory legislation governing matters such as waste disposal, noting this legislation is rarely targeted to single chemicals. Alternately, a national framework could be put in place to establish management controls throughout the full chemical lifecycle. The Government will consult with state and territory governments on the way forward.

All of the regulation options would make Australia compliant with the Stockholm Convention requirements for access to PFOS imports.[8] This would address the risk of interrupted access to imported supplies of PFOS for essential uses, particularly X-rays. It would also assist the metal plating and plastics etching industries, by ensuring that businesses that have not yet adopted PFOS substitutes have time to prepare for an orderly transition.

If Australia does not act and the current trend continues, the burden of PFOS exposure on Australian environments and communities will increase while Australian businesses will continue to be exposed to the risk of potential interruptions to the import of essential supplies of PFOS.

The proposed regulation of PFOS would be financially prudent as it would:

- provide continued access for Australian industry to PFOS-containing essential imports.
- avoid the risk of costs, those that are currently unquantifiable, from future PFOS emissions due to the effects on the environment and, potentially, human health (if PFOS is proven to adversely affect human health).

The monetary value of the expected environmental improvement is difficult to establish. This reflects the uncertainties associated with the impacts of PFOS, the long timeframe for demonstrable impacts to become apparent and the interconnectedness and complexity of the relevant ecosystem processes. The limited ability to estimate financial impacts is characteristic of environmental regulation. Governments regulate environmental impacts on behalf of society in order to avoid not only environmental costs but also flow-on economic and social costs. The need for regulation arises due to market failure, i.e. because the cumulative financial impact of these costs is not adequately reflected in the market and is often subject to significant data gaps and uncertainty.

Qualitative analysis of the potential impacts of PFOS provides a way to identify and describe many of these unquantifiable costs and benefits. The non-quantified benefits include the maintenance of recreational values, the protection of biodiversity, including vulnerable native species, and the protection of ecosystem services. There is also a social benefit to the Australian community through improved peace of mind regarding the uncertain health and environmental impacts of PFOS contamination. This will have flow-on economic benefits that are also unquantifiable at this stage, through the avoidance of localised market disruptions due to PFOS contamination such as fishing closures or difficulty in selling residential property.

To inform the impact analysis, the Department of the Environment and Energy (the Department) commissioned an independent cost benefit analysis on Options 2 to 4. The Department subsequently updated the independent cost benefit analysis with the base case

[8] Australia would ratify the listing of PFOS under Options 3 and 4 while under Option 2, although Australia would not ratify the listing, it would still satisfy the conditions for certification of PFOS imports.

represented by Option 1 in this RIS. *Attachment E* provides these supplementary calculations on costs and benefits.

The analysis showed that the highest benefit to Australia at the lowest cost would come from Option 4. This option would maximise the reduction of PFOS emissions in the shortest possible timeframe, preventing more than 97 per cent (or 25.12 tonnes) of emissions over the next twenty years, with a projected regulatory impact of about $4 million per year.[9] The majority of costs in this option relate to the requirement for environmentally sound disposal of existing PFOS stocks at the standard set by the Stockholm Convention. The other options would involve a higher regulatory burden due to higher ongoing costs from the additional requirement for appropriate waste management by industries that continue to use PFOS, particularly for fire fighting uses.

The accelerated phase out of PFOS use under Option 4 would:

- reduce the potential for further environmental contamination from PFOS
- avoid considerable ongoing costs to industry for appropriate PFOS waste management
- provide the most certainty for industry in response to the global agreement to phase out PFOS under the Stockholm Convention.

Conclusion

Although the base case presents the lowest cost to business, it does not deliver the significant but currently unquantifiable benefits that would accrue from preventing further environmental emissions of PFOS. Its cost profile also relies on the assumptions of no additional regulation by states and territories and no interruption of imports. Unlike the other options, it is not consistent with the accepted international standard for the management of POPs under the Stockholm Convention.

Options 2 and 3 would reduce PFOS emissions by over 90 per cent, delivering significant but currently unquantifiable environmental benefits. These options present the highest costs to business, due to the requirement for businesses to implement best practice disposal of wastes while continuing to use PFOS. Option 2 would implement the minimum action required to assure the ongoing availability of imports from countries that have ratified the Stockholm Convention. Option 3 would add to this the ratification of the Stockholm Convention and the registration of ongoing uses of PFOS. Both of these options would deliver certainty to industry, including a transition period for businesses phasing out the use of PFOS.

Option 4 would reduce PFOS emissions by over 97 per cent, delivering the maximum environmental benefit, and presents a low cost to business. Under this option, the Government would work with states and territories to ban the use of PFOS except for its essential use in

[9] Note that there are differences between ‘costs’ and ‘regulatory burden’ figures. Total costs include all quantifiable costs (in this case both industry and government costs), and are present values (discounted using a 7% discount rate over a 20 year period). Meanwhile regulatory burden figures are calculated as simple annual averages of compliance costs by industries over the first ten years. The calculation of the costs figures follows OBPR’s Guidance note on Cost Benefit Analysis (OBPR, 2016c), while the regulatory burden figures are calculated based on OBPR’s Guidance note on Regulatory Burden Measurement Framework (OBPR, 2016d).

medical imaging, with a five year phase out for other uses. This option avoids the risks associated with ongoing PFOS use.

All the options reflect the fact that chemicals management in Australia is a partnership between the Australian Government and state and territory governments, in consultation with industry and the community. The Government is therefore seeking the views of all stakeholders on the best way to manage PFOS, keeping in mind the critical need to secure Australia's continued access to essential PFOS imports.

Consultation

The Department is releasing this RIS to inform consultation with all stakeholders including state, territory and local governments, industry and the wider community. The feedback from consultation will inform the development of a final RIS for consideration by the Government.

The Department is seeking feedback on the options presented in this RIS from industry groups, businesses, members of the community, state, territory and local governments and any other interested party.[10] Comments are sought on the suggested options for government action, the data and assumptions underpinning those options and the data gaps identified in the impact analysis. Information is, for example, sought on:

- How industry capacity can be best mobilised to achieve the proposed PFOS phase outs, process improvements, and waste disposal and destruction requirements
- Additional information that would help to substantiate, or refine the accuracy of, the analysis of costs and benefits
- For fire fighting, information on the current import, use, storage, and stocks of PFOS-containing fire fighting foams, including use in shipping
- For chromium plating, information on the current import, use, storage stocks and disposal pathways of PFOS and, where it is used, the proportion of systems that are open-loop as opposed to closed-loop
- For X-ray photography and other medical uses, information on the current extent of use and service life of devices, and any data on non-PFOS alternatives or replacement technologies that would inform cost benefit analysis calculations
- For aviation hydraulic fluids, information on the current use of PFOS-containing aviation hydraulic fluids in Australia, if any, including any data that would inform cost benefit analysis calculations, as well as where such fluids are disposed of at end of life
- For pesticides, information on any current or historical use of PFOS including as surfactants or other listed or unlisted constituents in Australia
- Implementation mechanisms for biosolids and leachate management and the feasibility of the proposed approaches

[10] For further information on the consultation process and making a submission, see Section 7.

- The appropriate division of implementation responsibility across the Commonwealth, states and territories and, if appropriate, local government
- Information on whether any complex PFOS derivatives listed in *Attachment A* are currently used in Australia.

CONTENTS

1. INTRODUCTION

1.1 Purpose

This regulation impact statement (RIS) explores options to protect human health and the environment by reducing and ultimately eliminating emissions into the environment of perfluorooctane sulfonate (PFOS) and its related chemicals, in recognition of their persistent, bioaccumulative and toxic nature.

The objective of taking government action is to minimise the potential impacts of PFOS on the environment and human health by limiting future exposure as a precaution. PFOS is being phased out worldwide due to its risks to the environment and potential risks to human health. Although there are no proven health effects, it is possible that PFOS exposure could affect human health.

PFOS is a fully fluorinated synthetic chemical substance that is highly stable due to the strength of the carbon-fluorine bonds. It was widely used during the twentieth century as an industrial chemical in applications that made use of its surface activity and its heat, chemical and abrasion resistance. A global phase out began in 2001 after concerns were raised about its persistence in the environment, presence in the blood of humans and wildlife, and potential for long-term health and environmental effects.

PFOS is recognised as a persistent organic pollutant (POP) under the Stockholm Convention on Persistent Organic Pollutants (the Stockholm Convention) described in Box 1. The Stockholm Convention sets out internationally accepted standards to restrict the production, import, export, use and disposal of POPs. The listing of PFOS signals international acceptance by scientific experts and governments of associations between PFOS exposure and various adverse human health and environmental effects. It also demonstrates an international commitment to minimise further releases of PFOS that could cause long term or irreversible harm.

Box 1. The Stockholm Convention on Persistent Organic Pollutants

The objective of the Stockholm Convention on Persistent Organic Pollutants (POPs) is to protect human health and the environment from the effects of POPs. The Convention sets out a range of control measures to reduce and, where feasible, eliminate POPs releases, including emissions of by-product POPs or through unintentional releases. The Convention also aims to ensure the sound management of stockpiles and wastes that consist of, contain or are contaminated by POPs. See Box 8 for further details of the management requirements under the Stockholm Convention.

A POP is a chemical that, persists in the environment, accumulates in the food chain, has potential for long range transport and has evidence for adverse effects or for potential for damage to human health and the environment, even at low concentrations. Due to their long-range transport, persistence and toxicity, POPs released in Australia and overseas have the potential to affect the health and environment of Australians.

The options considered in this RIS are all designed to deliver a reduction in Australia's PFOS emissions by diverting future environmental releases of PFOS to waste treatment capable of destroying the PFOS content, consistent with the requirements of the Stockholm Convention. Although the base case of no action is also likely to deliver a gradual reduction in PFOS emissions, it does not ensure PFOS destruction and is not consistent with the global standards for sound management as set out in the requirements of the Stockholm Convention.

The implementation arrangements for a phase out of PFOS would be subject to consultation with those responsible for managing it, which includes users and regulators. In Australia the regulation of chemicals and wastes is a shared responsibility across all levels of government. See Box 2 for an outline of these roles and responsibilities.

Box 2. Chemical and waste management roles and responsibilities in Australia

The Constitution establishes the roles and responsibilities of the Commonwealth, state and territory governments. State and territory governments delegate some functions to local governments and regional authorities. The three levels of government share responsibility for regulating chemicals, such as PFOS, and managing their environmental and health impacts.

The Australian Government is responsible for national and international matters relevant to chemicals, such as risk assessments and border control. The Government's role in the regulation of PFOS therefore focuses on national-level coordination and regulation along with international engagement, including border control, to support the actions taken by states and territories. It also manages Commonwealth land, including the Defence estate.

State and territory governments are responsible for regulating chemical use, waste disposal (including destruction) and environmental impacts (including contamination) and for providing fire and emergency services.

States are starting to announce policies to control the use and disposal of PFOS and its related chemicals, particularly in fire fighting. Such action is taken under relevant state or territory legislation with varying dates of commencement.

The matters delegated by state and territory governments to local government (including regional authorities) can vary, but typically include land use planning, environmental health, water supply and waste disposal. Local governments, water authorities and waste management authorities are closely involved in efforts to address the impacts of PFOS.

In Australia, there is a general principle that the person or company taking an action that could cause potential harm, such as the release of a chemical into the environment, is responsible for the harm. It is good practice for chemical users and waste managers to exercise due diligence, or take reasonable precautions to avoid harm. Polluters can incur liability for the cost of managing pollution under the polluter pays principle.

Following consultation on this RIS with governments, industry and the community, the Australian Government could decide to take no further action, to adopt the minimum requirements under the Stockholm Convention for certification of imports, or to ratify the Stockholm Convention listing of PFOS.

Ratification could involve Australia registering for some or all of the current known uses of PFOS, or registering for the one identified essential use of PFOS in Australia, which is in medical imaging, principally X-ray photography.

1.2 Report structure

This RIS is structured as follows:

- *Introduction* provides an overview of the RIS, its purpose and structure.
- *What is the policy problem we are trying to solve?* outlines the policy problem presented by PFOS, including its chemical characteristics, impacts, the measures already in place to control it and its current uses by industry.
- *Why is action on PFOS needed?* explains the need for action to achieve sound management of PFOS, sets out the objectives, identifies potential intervention points and explains why government action is needed to deliver on these objectives.
- *What are Australia's options for the phase out of PFOS?* presents options for Australia to phase out PFOS, including the base case of business as usual i.e. no government action.
- *What are the impacts of the options?* evaluates the impacts of the options for communities (including individuals), businesses and government, drawing on a cost-benefit analysis and a qualitative analysis of benefits that cannot currently be costed.
- *How will Australia's phase out of PFOS be implemented?* identifies legislative options for implementation, including the requirements for environmentally sound management of PFOS wastes.
- *Consultation* provides information on the consultation process for the RIS, including how to make a submission.

The attachments provide additional information as follows.

- *Attachment A* is a list of PFOS-related substances
- *Attachment B* is a list of references for the discussion of environmental and potential human health impacts of PFOS
- *Attachment C* provides details of the OBPR Regulatory Burden Measurement
- *Attachment D* is a list of reports that have informed the RIS
- *Attachment E* provides details of the assumptions and analysis underpinning the cost-benefit analysis
- *Attachment F* provides data on projected emissions
- *Attachment G* provides profiles for industries currently using PFOS
- *Attachment H* provides a glossary and abbreviations.

2. WHAT IS THE POLICY PROBLEM WE ARE TRYING TO SOLVE?

In Australia, the environment and human health are not adequately protected from potential harms associated with PFOS exposure. PFOS is known to affect the environment, including wildlife, and may affect human health. Consequently, there is a strong case for government action to minimise further exposure to PFOS.

PFOS is already a ubiquitous low-level environmental pollutant with widespread human exposure because of its extensive past use and its intrinsic properties. Australia's use of PFOS in an environmentally dispersive manner, without containment of wastes such as the residues of fire fighting foams, has led to elevated PFOS levels at a number of sites (see Box 3).

PFOS is still used by some industries in Australia, although production is being phased out worldwide due to concern about its risks. There is currently no consistent national approach to the phase out of PFOS and under existing regulatory arrangements Australia is unable to restrict the import of PFOS or ensure sound management of PFOS wastes. The continued use and emissions of PFOS in Australia increase the likelihood of realising risks to the environment and, potentially, human health.

Minimising exposure to PFOS requires either stopping use or preventing emissions to the environment whenever PFOS is used. Currently, the main use of PFOS is in legacy stocks of fire fighting foam, deployed at major hazard facilities and other locations where flammable liquids are stored and used.[11] PFOS emissions from use in these circumstances can be difficult and expensive to control. Although other uses of PFOS such as chromium plating and X-rays are more contained, the wastes from these uses are not treated for PFOS. In summary, there is no consistent approach to the management and destruction of PFOS wastes to prevent emissions to the environment.

Conventional waste management, such as discharge to sewer or disposal to landfill that is not specially engineered to prevent discharge, is not appropriate for waste containing high levels of PFOS.[12] Because PFOS does not readily break down, landfills and sewage treatment plants become potential point sources of PFOS emissions. Research supports the use of high temperature incineration or plasma arc destruction for the environmentally sound destruction of PFOS in waste. Immobilisation and other methods to destroy and irreversibly transform PFOS waste may be possible for certain types of waste. However, in the absence of regulation, there is no way to guarantee the universal adoption of such safer methods of disposing of PFOS wastes.

Recent information on the extent of PFOS contamination around Australia and the impacts on local communities demonstrates the market failure resulting from PFOS use. The community and the environment, rather than polluters, are bearing the burden of the adverse

[11] The widespread past use of PFOS for fire fighting reflected its efficacy in fighting Class B fires in fuels and other flammable liquids at a wide range of locations such as airports, aircraft hangars, ports, ships and tug and fire boats, defence facilities, oil and gas refineries, tank farms, electricity generators, chemical manufacturing and storage facilities and mines.

[12] Waste with relatively low PFOS levels may be suitable for environmentally sound disposal in landfills that have infrastructure for leachate management. See Box 9 for information on the internationally accepted waste management requirements established by the Stockholm Convention.

impacts from PFOS use. Action is needed to strengthen the management of the use and disposal of PFOS to prevent further increases in levels of PFOS in the Australian environment. This will minimise the impacts and potential risks associated with PFOS exposure, and result in a more appropriate price signal for polluters.

Box 3. Contaminated sites in Australia

PFOS and related chemicals are being found at high levels in soil, groundwater and surface water at a growing number of sites nationally. In many cases, contamination is thought to have resulted from the use of PFOS-containing fire fighting foam concentrates for fire fighting or fire training, particularly at major hazard facilities. All levels of government in Australia are working to understand the extent of contamination within their jurisdictions.

The Commonwealth manages a range of sites that may be contaminated including airports and Defence estate. The Department of Defence is investigating whether PFOS and other PFAS chemicals are present at sites around Australia, with detailed environmental investigations at eleven sites as at June 2017 including Royal Australian Air Force Base Williamtown in New South Wales and Army Aviation Centre Oakey in Queensland.[13] Airservices Australia is investigating 36 airports nationally for contamination.[14,15]

The proposed regulation is consistent with the Government's principle of adopting trusted international standards and risk assessments. International action has restricted the global production, trade, use and disposal of PFOS in accordance with its listing under the Stockholm Convention (see Box 1, Box 7 and Box 8). The listing follows a decade of in-depth assessment of PFOS through the United Nations Environment Programme (UNEP) and the Organisation for Economic Cooperation and Development (OECD). Most likeminded OECD countries, including the United Kingdom, Germany, Japan and New Zealand, have ratified the Stockholm Convention listing of PFOS. The main global PFOS supplier, China, has also recently ratified the listing.

The absence of an Australian government decision on ratification of the Stockholm Convention listing of PFOS creates uncertainty for industrial users of PFOS, particularly for businesses reliant on imports rather than existing stocks, such as chromium platers. Under current arrangements, PFOS imports - including for essential uses such as X-rays - could be interrupted because Australia is not a Party to the Stockholm Convention with respect to PFOS, and is unable to ratify its listing or provide certification of the appropriate disposal of PFOS waste (see Box 11 for further information on certification).

In the absence of action to address these regulatory failures in the sound management of PFOS throughout its lifecycle, the Australian population and environment will continue to be at risk, communities will bear the burden of future contamination, and industry will operate with uncertainty.

[13] http://www.defence.gov.au/id/PFOSPFOA/DefenceSites.asp

[14] http://www.abc.net.au/news/2016-08-24/36-airports-across-aust-monitored-toxic-foam-contamination/7779616

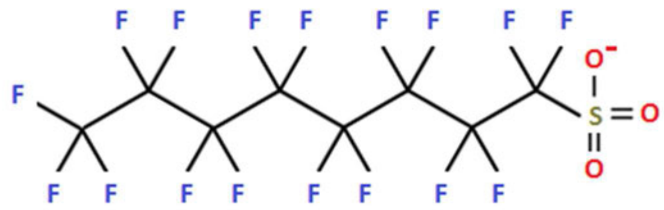
[15] http://www.airservicesaustralia.com/wp-content/uploads/Airservices-Australia-Senate-Enquiry-Submission-Part-B.pdf

2.1 What is PFOS?

Perfluorooctane sulfonic acid (PFOS) and its related chemicals belong to a group of synthetic (artificial) chemicals known as per- and poly-fluoroalkyl substances (PFAS).[16] Annex B of the Stockholm Convention lists a number of PFOS-related chemicals including the "parent" acid perfluorooctane sulfonic acid, its salts, and perfluorooctane sulfonyl fluoride (PFOSF).[17,18,19] Although Annex B does not specify the more complex PFOS derivatives, the listing of PFOSF is intended to capture these chemicals because PFOSF is the intermediate thought to be used for production of all PFOS-related chemicals.[20] The term PFOS is generally used in this RIS to cover all PFOS-related chemicals, including any currently permitted for use in Australia that are listed at *Attachment A.*

In chemical terms, the linear perfluorooctane sulfonate anion is a fully fluorinated (perfluorinated) alkyl sulfonate with the chemical formula $C_8F_{17}SO_3^-$. PFOS occurs in both linear and branched forms. The common characteristic of PFOS-related chemicals is the $C_8F_{17}SO_2R$ moiety, where R may represent OH molecules, a metal or other salt, a halide, an amide, or other derivatives including polymers. These derivatives can break down over time in living organisms or in the environment to produce PFOS. See Figure 1 for the chemical structure of the linear perfluorooctane sulfonate anion.

Figure 1. Linear perfluorooctane sulfonate



PFOS is highly stable due to the strength of the many carbon-fluorine bonds. As discussed above, PFOS-related chemicals include the "parent" acid (perfluorooctane sulfonic acid), its salts (the perfluorooctane sulfonates), and a range of more complex polyfluorinated chemicals and polymers that contain PFOS as part of their chemical structure.[21] The useful properties of PFOS include repulsion of both grease and water and resistance to acid and heat. It is stable to environmental degradation and to metabolic degradation, with a potentially long half-life in animals and humans. See section 2.2, *What are the impacts of PFOS?* for more information about the relationship between these properties and the impacts of PFOS.

[16] Examples of other PFASs include perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS).
[17] The CAS reference for perfluorooctane sulfonic acid is CAS No: 1763-23-1.
[18] For example: potassium perfluorooctane sulfonate (CAS No 2795-39-3); lithium perfluorooctane sulfonate (CAS No: 29457-72-5); ammonium perfluorooctane sulfonate (CAS No: 29081-56-9); diethanolammonium perfluorooctane sulfonate (CAS No: 70225-14-8); tetraethylammonium perfluorooctane sulfonate (CAS No: 56773-42-3); and didecyldimethylammonium perfluorooctane sulfonate (CAS No: 251099-16-8).
[19] The CAS reference for PFOSF is CAS No: 307-35-7.
[20] The starting point for manufacture of all PFOS-related chemicals is believed to be the electrochemical fluorination process, which produces a mixture of PFOSF and other byproducts.

2.2 What is PFOS used for in Australia?

Analysis by the Department including testing of imported articles indicates that current uses of PFOS in Australia include fire fighting foams, metal plating, plastics etching, medical imaging such as X-ray photography, and potentially aviation hydraulic fluids. In the past, PFOS was also used in a wide variety of industrial and consumer applications such as textiles and leather surface treatments, food packaging, floor polishes, denture cleansers, shampoos, coatings and coating additives, and in the photographic and photolithographic industry. Analysis to date indicates these are no longer current uses and articles containing PFOS chemicals will have already been disposed of.

PFOS-related chemicals are considered to be industrial chemicals in Australia. The Australian industrial chemicals agency, the National Industrial Chemicals Notification and Assessment Scheme (NICNAS), maintains the Australian Inventory of Chemical Substances (AICS) which lists the existing chemicals that can be imported or manufactured in Australia for the listed uses without further notification to or assessment by NICNAS.[22, 23]

Five salts of perfluorooctane sulfonic acid (PFOS) and PFOSF are publicly listed in the AICS, along with a number of other PFOS-related chemicals.[24] A complete listing is provided in Attachment A.[25] These chemicals are currently permitted for industrial use in Australia. Any PFOS-substances that are not listed on the AICS are not prohibited for use in Australia as industrial chemicals. They would however be subject to assessment by NICNAS as new industrial chemicals prior to their introduction.

2.3 What are the impacts of PFOS?

The Australian Government Office of Best Practice Regulation (OBPR) advises that accounting for environmental assets in a Regulation Impact Statement can be difficult "because the benefits that some of them provide can be hard to understand and because our scientific knowledge of many environmental processes is limited".[26] This is particularly pertinent in assessing the impacts of PFOS on the environment, living organisms and humans in Australia.

The approach used in this RIS to identify the environmental and potential human health impacts of PFOS uses the guidance and background research issued by the OBPR.[27, 28] It applies the analytical framework provided in the United Nations Millennium Ecosystem Assessment to assess ecosystem processes and services, as adapted by the UK Government for its 2011 National Environmental Assessment.[29, 30]

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[22] https://www.nicnas.gov.au.
[23] https://www.nicnas.gov.au/chemical-inventory-AICS.
[24] CAS Nos: 307-35-7, 2795-39-3, 29081-56-9, 29457-72-5, 56773-42-3, and 70225-14-8.
[25] Although many PFOS-related chemicals, including those listed, are not explicitly mentioned in the Stockholm Convention, the listing of PFOSF, which is an intermediate material in the production of PFOS-related chemicals, is considered to cover these chemicals and is likely to have impacted their global production and availability.
[26] OBPR (2016a).
[27] OBPR (2016b).
[28] OBPR (2014).
[29] United Nations Environment Programme Millennium Ecosystem Assessment (2003).
[30] UK National Ecosystem Assessment (2011).

2.3.1 Challenges in assessing the impacts of PFOS

There are significant challenges in assessing the impacts of PFOS, not least that the scientific evidence is continuously advancing.

Current evidence indicates that PFOS has environmental impacts, including on animal health, and may potentially affect human health. Studies in animals have shown significant developmental, reproductive and systemic effects. Multigenerational studies on fish indicate effects can be seen in offspring. Future research may find the negative impacts of PFOS to be more wide-ranging or more serious than we currently know, or conversely that some current concerns are no longer substantiated. In accordance with the precautionary principle, this scientific uncertainty should not delay cost-effective measures to prevent serious or irreversible damage to the environment.

Information to cost impacts of PFOS at relevant concentrations, over the time periods of likely exposure, is not currently available. Consequently, it is not possible to quantify the benefits of reducing PFOS emissions, making it difficult to directly weigh the evidence on impacts against the cost of taking action. International literature on cost-benefit analysis of PFOS regulation in comparable countries, such as Canada, indicates that is a common situation.[31] In many cases, countries decide to act based on policy decisions regarding risk, and follow a cost effectiveness approach for determining the scale of intervention. Research is unlikely to fill this gap in the short term. Australian research is largely focused on urgent priority issues such as improved contaminated sites management, the development of environmental and health standards, and environmental and epidemiological impacts.

2.3.1.1 Challenges in assessing environmental impacts

Assessing the evidence on the environmental impacts of PFOS in Australia is complicated by a range of factors. The following issues present particular challenges for environmental researchers, managers and policy makers in assessing any changes that may be taking place due to PFOS contamination.

Much of the available evidence on PFOS is from laboratory research rather than field research, as is usually the case for industrial chemicals. It is not always possible to draw firm conclusions about real-world impacts from changes observed - or not observed - in a laboratory setting. Standardised laboratory tests in aquatic species usually run for one to four days exposure (acute effects), or up to around 28 days (chronic effects). Such standard test periods may not be able to adequately address relevant exposure periods for PFOS chemicals.

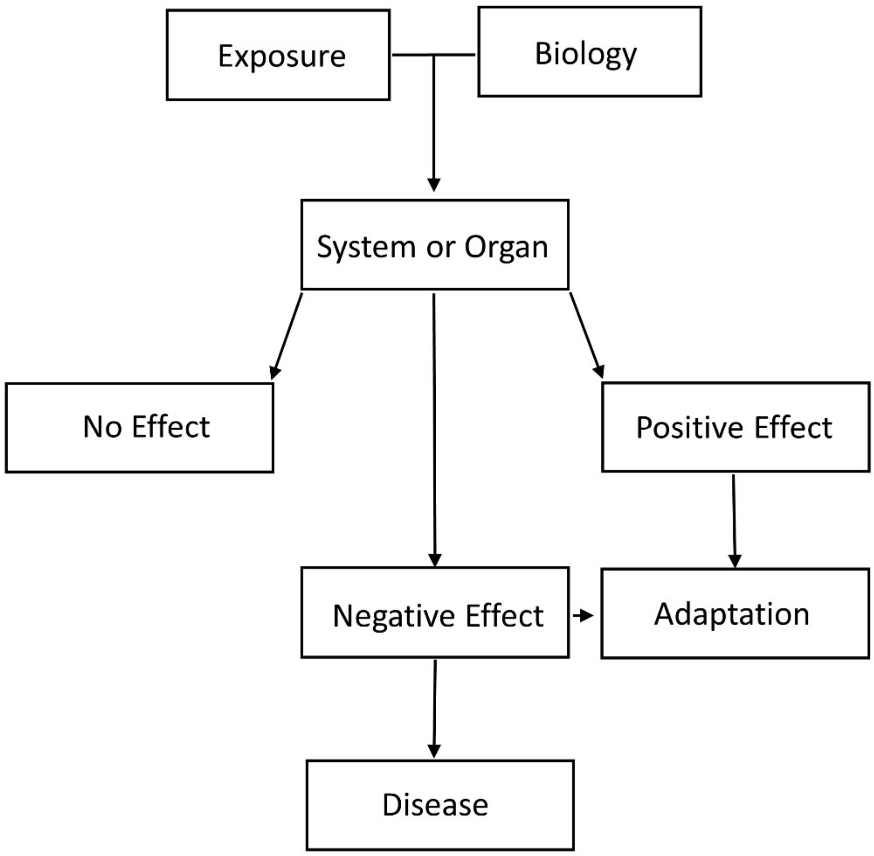
There are few data on PFOS in the Australian environment. This reflects the fact that the majority of research on chemicals is conducted on internationally agreed, standard test species. Existing field research on PFOS has often been undertaken in northern hemisphere ecosystems. The variability of the Australian environment, including cyclical processes such

[31] Environment Canada (2006) conducted an assessment of the costs and benefits of regulating PFOS. As well as monetary costs, the assessment identified monetary benefits due to avoided costs for alternate water supply. Due to limited data availability, however, it did not estimate the environmental, health, or social impacts or the wider economic impacts of PFOS regulation.

as drought and fire along with long-term trends such as habitat degradation and climate change, make identification of changes attributable to PFOS complex.

Finally, there are inherent challenges in identifying animal health impacts, from exposure to a stressor such as a chemical. As Figure 2 illustrates, when an animal is exposed to a chemical, the level of exposure interacts with its biology to determine how much of the chemical actually reaches each of its organs or body systems. The resulting chemical exposure may not lead to any measurable changes and even if such changes are found, they may not necessarily foreshadow disease.[32]

Figure 2. Effect of chemical exposure on animal health



2.3.1.2 Challenges in assessing human health impacts

Limitations also apply to the available data on potential human health impacts. For example, the gold standard for identifying – or ruling out – human health impacts from PFOS would be via a large scale, long term, scientifically robust, peer-reviewed quantitative meta-analysis of health effects derived from longitudinal and epidemiology studies. This standard of evidence is not available for PFOS.

[32] A key concept is reverse causality, for example where the level of a chemical varies due to a health condition, rather than the chemical causing the health condition.

As discussed above, some of the current studies on potential human health impacts identify possible associations but do not establish causality. The presence of a statistical association between elevated PFOS levels and a specific health effect is not, in itself, evidence that PFOS is the cause. The possible confounding factors include:

- People exposed to higher levels of PFOS in industrial areas are likely to be exposed to a wide range of other pollutants. It is very difficult to predict the effect of a complex mixture of chemicals that may have different, or even opposing, biological effects.[33]

- Exposure at the individual, household or community level may also differ due to local and behavioural factors. These can include the presence of localised soil and water contamination, weather patterns, and recreational and consumption behaviours. For example, people involved in recreational or commercial fishing may eat more seafood, and Indigenous communities may eat more wild food in general.

- Human populations can differ in their vulnerability to the health impacts of a potential stressor. This can depend on factors such as baseline health status (i.e. whether the person has pre-existing health concerns), nutrition, socioeconomic status and genetic heritage. Vulnerable groups can include young children, the elderly, people preparing for or undergoing pregnancy and people with compromised immunity. Consequently, the potential health impacts of PFOS exposure for one population may not apply for other populations.

The above factors present a challenge for researchers seeking to separate out the possible influence of PFOS from other factors affecting human health. The Australian Government Department of Health has commissioned an epidemiological study to examine the potential health effects resulting from exposure to PFASs, including PFOS.[34]

The following discussion reflects these uncertainties in relation to PFOS, its prevalence and transport and its effects on living organisms, including humans.

2.3.2 How are humans and the environment exposed to PFOS?

Existing environmental loads of PFOS contamination in Australia reflect the history of its use since the 1950s. During most of this time, there was little or no restriction on PFOS imports, sales and disposal. PFOS is expected to have entered the environment through the use of products such as PFOS-containing fire fighting foam, and, to a lesser degree, through sewerage discharge and the disposal of trade waste and consumer products to landfill. Recent information indicates that resulting contamination may be widespread, possibly comprising hundreds of sites with elevated PFOS levels.

The common presence of PFOS in human tissue, breast milk and blood provides evidence of low level PFOS exposure across the population. Humans, along with animals, are mainly exposed to PFOS through their surrounding environment. PFOS enters the body through a

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[33] Bonefeld-Jorgensen et al (2014).

[34] http://www.health.gov.au/internet/main/publishing.nsf/Content/44CB8059934695D6CA25802800245F06/$File/PFAS-ANU-Study.pdf

variety of processes with water, food, soil, dust and air all potential pathways for exposure. Foetal exposure can also occur through transfer across the placenta.

As a widely dispersed anthropogenic contaminant, PFOS is now found at low levels in the environment worldwide including in locations and wildlife far from direct human sources, such as in the polar regions.[35] This is characterised as “background” concentration, noting that use of the term “background” does not imply a specific level of risk. Low-level exposure to diffuse sources of PFOS therefore occurs even in the absence of nearby point sources of emissions. Because PFOS is so persistent (it resists environmental degradation processes, including atmospheric photo-oxidation, direct photolysis and hydrolysis), it has a half-life in the environment of greater than 41 years.[36] Levels in the environment therefore decrease extremely slowly and all new emissions add to the existing burden of PFOS, further increasing overall exposure long after emissions stop.

Point sources of PFOS create the potential for higher levels of exposure nearby. In Australia, higher levels of PFOS tend to occur in urban areas, particularly within, near, or downstream from industrial zones, and in enclosed waters such as lakes, harbours and estuaries.[37] On land, contaminated sites are point sources of exposure. Contaminated sites are locations where a chemical substance, such as PFOS, is present above background levels. Fire fighting is the most environmentally dispersive use - see Box 4 for examples of the PFOS levels that can result from fire fighting. Elevated PFOS levels in soil can also result from the land application of PFOS contaminated biosolids from sewage treatment. Contaminated sites present a risk, or potential risk, of ongoing adverse health or environmental impacts. Even when the PFOS level declines at a contaminated site, this is likely to indicate contamination spreading off-site into the surrounding environment, rather than the chemical breaking down on-site.[38, 39]

35 The term anthropogenic means caused or produced by humans
36 United Nations Environment Programme Persistent Organic Pollutants Review Committee (2006).
37 Gaylard (2016).
38 *National Environment Protection (Assessment of Site Contamination) Measure 1999* as amended and in force on 16 May 2013 at https://www.legislation.gov.au/Details/F2013C00288.
39 The distribution of PFOS off-site reflects geology and hydrology. In surface water and groundwater it may travel as a plume of elevated PFOS, or be diluted widely at lower levels.

Box 4. Case study - Environmental contamination from use of fire fighting foam

Uncontained releases of aqueous film-forming foams (fire fighting foam) from fire fighting systems, whether during an emergency or following a system malfunction, can contaminate the surrounding environment.

Researchers studied levels of PFOS in water and fish following the accidental release of PFOS into a creek in Canada in 2000.[40] Around 22,000 litres of fire fighting foam and 450,000 litres of water escaped from the sprinkler system at an airline hangar at the Toronto international airport.

The PFOS levels in surface waters, expressed in terms of micrograms per litre (µg/L), reached a maximum of 2210 µg/L 15 km downstream two days after the spill. The PFOS levels at the end of the sampling period, 153 days after release, ranged from 0.19 to 0.44 µg/L. The study also found very high levels of PFOS in the liver tissues of fish living in the creek, although it noted that some of this could reflect existing PFOS contamination from the airport, or other sources in the creek catchment, rather than the immediate effects of the spill.

The volume of fire fighting foam discharged from the hangar fire system in Toronto is considered representative of how fire fighting foam is used at Australian major hazard facilities.[41] The use of PFOS-containing fire fighting foam in Australia, without adequate controls to prevent its entry into waterways, could lead to similar incidents of environmental contamination.

Exposure to chemicals that bioaccumulate and biomagnify is concerning because even when the source of exposure is removed, poor elimination from the body can result in ongoing exposure and prolong any effects of the chemical. PFOS is known to be highly bioaccumulative reflecting that the rate of intake is generally faster than the rate of elimination from the body.[42] It is known to bind to proteins in the blood and liver in animals, is not metabolised and is poorly excreted, particularly in air-breathing mammals.[43] PFOS also biomagnifies, meaning that the levels measured in animals tend to increase up the food chain. Figure 3 is a simplified diagram of biomagnification in an Australian marine ecosystem, including examples of the biota found at each trophic level.

[40] Moody et al (2002).

[41] A major hazard facility is a site where large quantities of hazardous materials or dangerous goods are stored, handled or processed.

[42] The half-life in humans is approximately 5.4 years but can be shorter (days to months) in some other mammals (ATSDR 2015; FSANZ 2017).

[43] Respiration through gills provide an additional excretion pathway for water-breathing animals.

Figure 3. Simplified Australian marine ecosystem

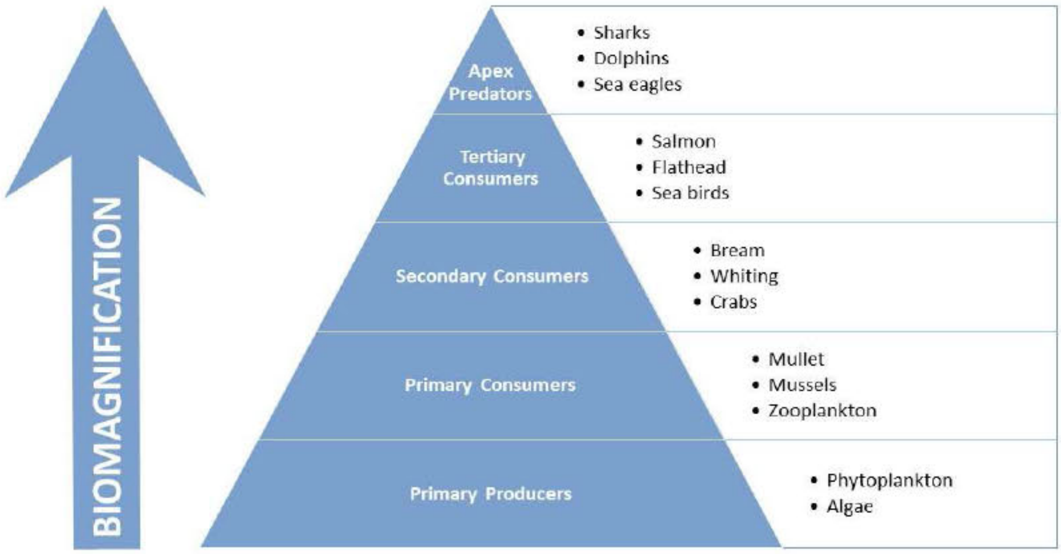


Table 1 illustrates biomagnification in Arctic ecosystems (where levels of PFOS can be up to 2,000 times higher in the apex predator, the polar bear, compared to zooplankton) and in the Port River, at Port Adelaide South Australia.[44]

Table 1. PFOS levels in marine ecosystems

Trophic level	Arctic		Port Adelaide, South Australia[45]		
	Animal	PFOS (ng/g)	Animal	PFOS mean (ng/g)	PFOS range (ng/g)
Apex	Polar bear	3,770	Bottlenose dolphin - liver	1,986	510-5000
Tertiary	Seal	95.6	Salmon - liver	65.25	44-120
Secondary	Fish	5.7-39	Bream - liver	2.43	0.81-5.60
Primary	Zooplankton	1.8	Mussels - flesh	0.68	0.5-0.86

2.3.2.1 What is the evidence on PFOS exposure pathways?

The Department has modelled the lifecycle of PFOS and its material flows into the environment to determine current exposure pathways and their magnitude. The information presented here draws on a range of independent research and consultation with industry and other stakeholders. It forms the basis of the analysis presented later in this RIS to identify the most efficient and effective points for regulatory intervention.

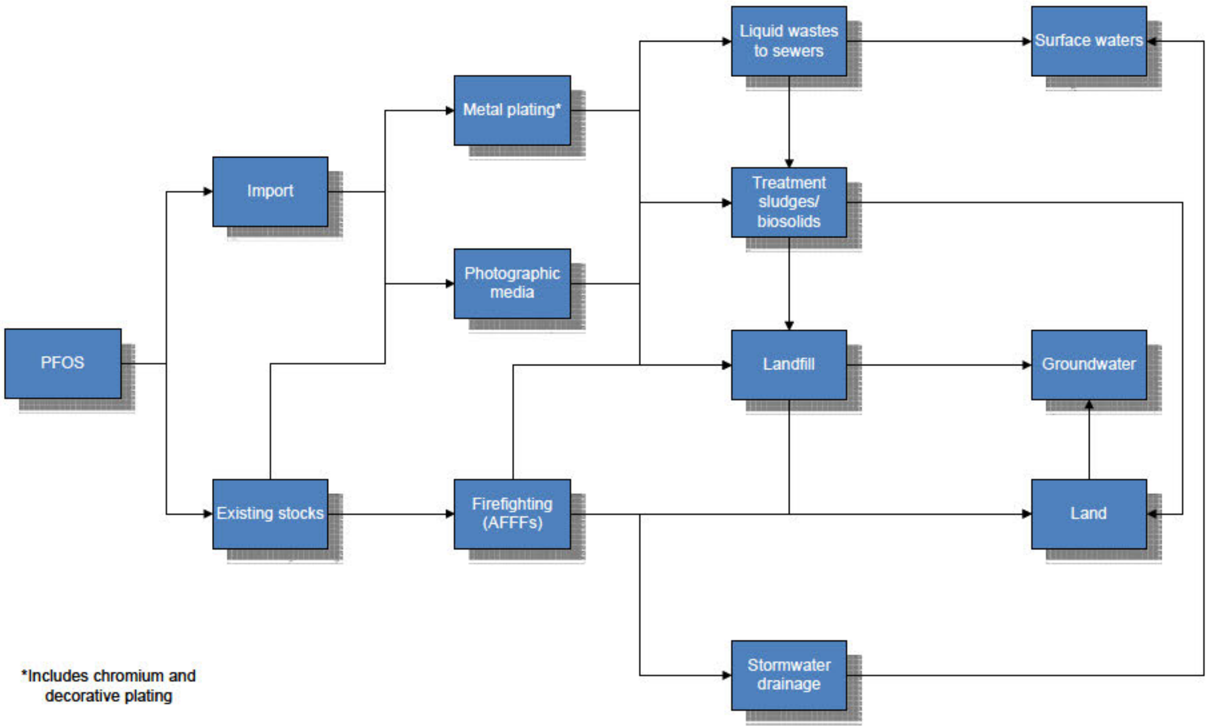
The main stages of a chemical lifecycle are production, formulation of chemical mixtures or articles, use (including industrial, commercial or consumer use) and disposal (which includes

[44] The average PFOS levels in Swan River dolphins in Western Australia are even higher, ranging up to 14,000 ng/g, among the highest in the world (Gaylard, 2016).
[45] Values for mussels were sampled in the flesh while the rest were sampled in the liver.

destruction). Each stage may result in releases of PFOS into the environment. PFOS emissions vary depending on the stage and use, which can influence the amount of PFOS released into the environment and the nature of any environmental contamination. The environmental fate of PFOS emissions will be determined by how the chemical interacts with the surrounding environment.

Figure 4 illustrates the key pathways by which PFOS is expected to enter the environment in Australia because of use and subsequent non-environmentally sound disposal practices. It is important to note, however, that this is a simplified conceptual model developed for the cost-benefit analysis that does not attempt to capture all of the movement of PFOS into and within the environment.[46] The key feature of the PFOS lifecycle in Australia is the absence of emissions from the first two stages shown, because PFOS is not manufactured domestically and is thought not to be imported for formulation in other products. Almost all releases are thought to arise from emissions or disposal of wastes from a limited number of uses in industrial or commercial settings. Analysis indicates that PFOS is largely no longer imported in finished articles and hence these are not included in the model. Emissions from landfills will also include any releases from articles that have already been disposed of. The main emission sources are direct releases from use in fire fighting and waste streams going to sewers and landfill. Waste infrastructure is a potential secondary source of emissions. The estimated environmental fate of the PFOS emitted by each industry is shown in Table 2.

Figure 4. Simplified conceptual model of the life cycle of PFOS in Australia



[46] For example, this simplified conceptual model does not include the total environmental load, which would also include air emissions, long-range atmospheric transport, and movement between surface water and ground water.

Table 2. Estimated fate of PFOS by industry

Fate[47]	Hard chromium plating	Decorative chromium plating	Fire fighting[48]	Photography[49]
Destroyed	49[50]	5	-	22[51]
Surface water	6	61	65	1
Groundwater	2	8	10	13
Land – direct use or in biosolids	24	15	14	-
Landfill – in biosolids	19	12	11	-
Landfill – in products	-	-	-	64
Total (%)	**100**	**100**	**100**	**100**

The above discussion of human and environmental exposure to PFOS reflects the baseline scenario for this RIS, i.e. the continuing slow decline of PFOS use over the 20 years to 2036-37 in line with current trends. However, it is important to note that a major emergency or accidental release of PFOS-containing fire fighting foam, for example in response to an industrial accident at a major hazard facility, could interrupt this trajectory of decline. A major release of point source PFOS pollution would lead to significantly intensified exposure.

2.3.3 What are the environmental impacts of PFOS?

The known environmental impacts of PFOS reflect its chemical properties and their impacts on biota, or living organisms. There is no evidence to suggest that PFOS directly affects physical aspects of the environment such as hydrology, climate, or soils.

Research suggests that PFOS is associated with a range of impacts on ecosystem services, as shown in Table 3, and animal health, as shown in Table 4. Prevention or reversal of these impacts would deliver environmental benefits. These would in turn deliver economic and social benefits as described in Table 13 and Table 14 respectively.

As discussed elsewhere in this RIS, contaminated soil is a key environmental impact of PFOS. As a high volume waste, often with low levels of PFOS, contaminated soil usually incurs very high removal, treatment and disposal costs per site. It can leach PFOS into underlying sediments and groundwater, particularly in high rainfall environments, during extreme weather events, or during disturbance of the soil (such as construction and development activities). Soil replacement can also be very expensive with the cost

[47] Percentage totals may not add up to 100 due to rounding.
[48] These are the emissions from use of fire fighting foam for fire fighting and training purposes.
[49] These are the combined emissions from use and disposal of existing photographic materials.
[50] This assumes a proportion of PFOS is destroyed by the electrolysis process.
[51] This assumes a proportion of PFOS is destroyed by the recycling process for photographic materials.

depending on whether replacement soil is available locally and the subsequent land use purpose.[52]

Table 3. Ecosystem impacts of PFOS exposure

Type[53]	Air impacts	Land impacts	Water impacts	Biota impacts
Supporting ecosystem services: water cycle, nutrient cycle, soil formation, primary production, habitat	↑ adsorption of PFOS to airborne particles ↑ deposition of contaminated particles on ground, built environment & water ↑ PFOS vapour ↑ PFOS vapour exchange with oceans	↑ PFOS contaminated soil and substrate ↑ PFOS contaminated aquatic sediments ↑ PFOS contaminated biosolids ↑ PFOS leaching to surface water & groundwater ↑ bioaccumulation from soil	↑ PFOS in groundwater ↑ PFOS in surface water ↑ PFOS in precipitation	↑ chronic PFOS exposure ↑ acute PFOS exposure ↑ total body burden of toxins ↑ animal health effects of PFOS exposure ↑ bioaccumulation & biomagnification ↓ biodiversity ↓ ecological resilience
Provisioning ecosystem services: nutrition, materials, energy	none identified	↑ contaminated land ↑ land use conflicts ↓ land suitable for development ↓ aquatic & marine high conservation value areas	↓ surface water quality ↓ groundwater quality ↓ rainwater quality	↑ closures to fishing and aquaculture ↓ wild and home-grown food safety / quality assurance ↓ livestock & crop quality assurance
Regulating ecosystem services	↓ ambient air quality ↑ total area with airborne PFOS contamination	↑ total area and number of sites with PFOS contamination in soil & substrate	↑ total area and number of sites with PFOS contamination in surface water & groundwater	↑ total area and number of sites with PFOS contamination in biota ↓ wastewater filtration in wetlands ↓ pollination
Cultural ecosystem services: outdoor activities, knowledge generation, spiritual & symbolic values	none identified	↓ recreational gardening	↓ swimming and diving ↓ recreational boating	↓ recreational fishing ↓ recreational hunting & wild food gathering
	↓ perception of environmental quality, safety and sound management ↓ aesthetic value of flora, fauna, and ecosystems ↓ existence value of flora, fauna and ecosystems ↓ spiritual and cultural value of flora, fauna and ecosystem assets and traditional practices for Indigenous people			

Notes:
↑ = increase
↓ = decrease

52 Das et al (2016). Although higher levels of clay and organic matter may be protective against bioaccumulation Australian soils are typically low in clay and organic matter.
53 Ecosystem services categories are consistent with OBPR (2016b).

Research has identified a range of effects in animals that are associated with exposure to PFOS in the nervous, reproductive, immune, digestive and endocrine systems (examples are summarised in Table 4). However, the evidence on potential modes of action for these effects is not conclusive and requires further research.

Table 4. Examples of animal and plant impacts of PFOS exposure

Body System	Study finding regarding PFOS exposure	References[54]
Nervous system	Neonatal exposure associated with irreversible changes in mouse brain development and adult mice brains	Johansson et al. (2008) Johansson et al. (2009)
Mortality, reproductive system, development, endocrine system and genetics	Weight loss and poor growth in animals	York (1999)
	Thyroid hormone variations in *Cynomolgus* monkeys	Seacat et al. (2002)
	Growth retardation in rat / mice pups	Lau et al. (2003)
	Reduced foetal weight and deficits in weight gain during pregnancy in rats and mice; thyroid hormone variations in rat dams and in pregnant mice	Thibodeaux et al. (2003)
	Mortality, impaired metamorphosis, and decrease in size of tadpoles at metamorphosis	Ankley et al. (2004)
	Reduced emergence in *Chironomus tentans*	MacDonald et al (2004)
	Mortality, impaired fecundity, changes in reproductive endocrinal chemistry, and alterations in ovaries of adult female fathead minnows	Ankley et al. (2005)
	Reduced neonatal survival in rat pups exposed to PFOS in utero suggesting effects on late-stage foetal development and decreased gestation length in the groups with higher PFOS exposure	Luebker et al. (2005a) Luebker et al. (2005b)
	Acute toxicity mortality and changes in endocrinal chemistry in five species of freshwater fish	Oakes et al. (2005)
	Mortality, reproductive impairment, thyroid changes, and transgenerational increases in mortality	Ji et al. (2008)
	Inhibited growth rate in freshwater algae, enhanced mitochondrial membrane potential and cell membrane permeability	Liu et al. (2008)
	Malformation and mortality of embryos and larvae following chronic maternal exposure, inhibited gonad growth in female zebrafish and irreversible liver changes in male zebrafish	Du et al. (2009)
	Mortality and impaired reproduction	Li (2009)
	Impaired egg hatching, slower larval development, greater larval mortality, and decreased metamorphosis success in damselflies	Bots et al. (2010)
	Estrogenic, developmental, and reproductive impairment	Han and Fang (2010)
	Epigenetic changes in livers of weaned rats exposed to PFOS in utero	Wan et al. (2010)

[54] For details of all references cited see *Attachment B*.

Body System	Study finding regarding PFOS exposure	References[54]
	Impaired embryonic growth, reproduction and development in zebrafish	Wang et al. (2011)
	Acute toxicity mortality and changes in reproductive endocrinal chemistry in zebrafish	Keiter et al. (2012)
	Endocrine modulation effects on the estrogen receptor and thyroid receptor in zebrafish	Du et al. (2013)
	Epigenetic changes in gonads of sea urchin	Ding et al. (2015)
	Mortality, impaired growth and reproduction and diminished feeding rates in water fleas *(Daphnia magna)* with parental exposure associated with adverse effects to offspring	Lu et al. (2015)
	Reduced embryo survival in birds	Nordén et al. (2016)
	Growth inhibition in frogs	San-Segundo et al. (2016)
	Reduction in testicular size and altered spermatogenesis in quails and mallards	Environment Canada (2017)
Immune system	Suspected immunotoxicity associated with elevated concentrations of PFOS in sea otters that died from infectious diseases, compared to otters that died from other causes	Kannan et al. (2006)
	Effects on the developing immune system in mice	Keil et al. (2008)
	Decreased mass of spleen and thymus and altered immunity function in mice	Zheng et al. (2009)
	Immune changes in mice	Peden-Adams et al. (2008) Fair et al. (2011)
	Associations between immune parameters in a highly PFOS-exposed dolphin population and serum PFOS concentrations	Fair et al. (2013)
Digestive system	PFOS detected in livers of dolphins, sea lions, otters and polar bears	Kannan et al. (2001) Kannan et al. (2006)
	Lipid accumulation in the livers of *Cynomolgus* monkeys exposed to high doses of PFOS	Seacat et al. (2002)
	Accumulation of PFOS in liver, increase in liver mass and liver toxicity in rats	Cui et al. (2009)
	Non-alcoholic fatty liver disease, one of the major causes of chronic liver injury, in zebrafish and mice	Wan et al. (2012); Tse et al. (2016)
	Altered markers of hepatic (liver) function in dolphins associated with PFOS concentration	Fair et al. (2013)
	Enlarged livers with histological changes and increased fat content in mice	Wang et al. (2014) Xing et al. (2016)
	Negative effects of perinatal PFOS exposure on glucose metabolism in adult mice	Wan et al. (2014)
	Tumours in rats	Dong et al. (2016)
	Hepatotoxic with effects including hepatocellular adenomas (benign tumours), peroxisome proliferation and increased liver weight	Environment Canada (2006); Environment Canada (2017)

Body System	Study finding regarding PFOS exposure	References[54]
Community assemblage changes	Mortality and zooplankton community impairment and simplification	Sanderson et al. (2004)

Numerous laboratory studies have assessed animal mortality due to acute and chronic PFOS exposure. Acute laboratory tests have been undertaken on invertebrates such as rotifers, flatworms, daphnids, mussels, shrimp and snails, and to a lesser extent on fish and amphibians (Hagenaars 2011; Li 2009; OECD 2002). Other studies have assessed morphological changes, such as valve closure in the mussel *Liguma recta*, malformations in the frog *Xenopus laevis*, immobility in the daphnid *Daphnia magna* and developmental effects in the zebrafish *Danio rerio* (Hazelton et al. 2012; Hagenaars 2011; Boudreau 2003; OECD 2002). Chronic laboratory studies of the effects of longer exposures to lower doses of PFOS have assessed effects on algae (Lui 2008; Bourdeau et al. 2003; OECD 2002), macrophytes (Hanson et al. 2005), crustaceans (Lu et al. 2015; Li 2009; Ji et al. 2008; Sanderson et al. 2004; Boudreau et al. 2003), insects (Bots et al 2015; MacDonald 2004), fish (Keiter et a. 2012; Han and Fang 2010; Ji et al. 2008; Ankley et al. 2005; Oakes et al. 2005) and a frog species (Ankley et al. 2004). For the species assessed, adverse effects were observed in survival, growth, and reproduction, with lower effect concentrations generally associated with impaired growth and reproduction.

An important limitation of laboratory tests is the difficulty of studying effects relating to bioaccumulation, endocrine activity, and multigenerational effects. Some multigenerational studies evaluating the effects of PFOS exposure on fish have reported changes in sex steroid levels and physical changes to livers and ovarian cells, which provide supporting evidence that exposure to PFOS can be linked to adverse effects in subsequent generations (Du et al. 2009; Ji et al. 2008; Ankley et al. 2005).

The potential for complex and unpredictable impacts from PFOS exposure, including multigenerational effects, is a concern. Persistent and bioaccumulative chemicals, of which PFOS is one, have the potential to produce long-term effects not readily identified through standard ecotoxicity tests. An example of this type of long-term effect is epigenetic change, or alteration of genetic regulation in animals and humans following exposure to a stressor such as a toxin. Research into epigenetic changes has identified associations with altered cardiovascular and immune function. For PFOS, research suggests there is a possibility of epigenetic effects as shown in Table 4.

Another limitation of laboratory tests is the difficulty in studying the effects of mixtures. When present in mixtures with other PFAS, laboratory studies indicate that PFOS may, in addition to toxicity, have conflicting or antagonistic effects on biological processes (Lu et al. 2015; Wei et al. 2009). This can limit the ability of laboratory studies to measure the cumulative impacts of PFOS on an organism.

These characteristics create uncertainty about the impacts of PFOS on future generations at the individual or population level. As a result, it is not currently possible to estimate a safe exposure concentration for such chemicals. The accepted management strategy is to minimise exposure to these chemicals as a precaution.

PFOS can pollute the environment, potentially decreasing biodiversity and degrading the quality of environmental assets such that they may no longer be suitable for human use. Highly contaminated land may be unsuitable for agricultural, residential or other sensitive uses such as schools or sports grounds. Highly contaminated groundwater and surface water may be unsuitable for drinking water, stock watering, irrigation, fishing and aquaculture, environmentally sensitive wetlands, or environmental waters used for recreation including sports and fishing. Box 5 provides examples of how PFOS contamination has affected the environment in Australia.

Box 5. Investigating PFOS contamination in the Australian environment

Biodiversity

Ramsar wetlands are internationally significant wetlands that are representative, rare or unique wetlands, or wetlands that are important for conserving biological diversity. The PFOS contamination at Williamtown in New South Wales may affect nearby wetlands including the Hunter Estuary Ramsar wetland, raising concerns over the health of its migratory shorebirds.

Provisioning and cultural ecosystem services

The NSW Environment Protection Agency has advised residents in the investigation area at Williamtown to minimise their exposure by: not using groundwater, bore water or surface water for drinking or cooking; not eating home grown food produced using contaminated water; moderating consumption of home grown food not produced using contaminated water; not swallowing groundwater and surface water when bathing, showering, swimming and paddling; and limiting the servings of individual species of fish and seafood caught in contaminated water.[55] Sampling found elevated levels of PFOS in local fish, crabs and prawns, leading to the temporary closure of fishing in September 2015 pending expert advice from the Williamtown Contamination Expert Panel. These fishing closures were lifted in October 2016, except for the closure applying to one species, Dusky Flathead, which was lifted in April 2017.[56, 57]

In the Northern Territory, elevated levels of PFOS were found in Ludmilla Creek and Rapid Creek in Darwin, which are culturally significant to the Larrakia Aboriginal Traditional Custodians.[58, 59] Aboriginal people were regularly using these creeks to fish and gather bush foods and were reported to be using water for domestic purposes. The NT Government erected signs warning against eating seafood from Rapid Creek, and have now advised that while testing detected levels of PFAS in aquatic foods like long bums, periwinkles, crustaceans and fish, those foods can be eaten without exceeding the national Health Based Guidance Values.[60, 61, 62]

2.3.4 What are the potential human health impacts of PFOS?

The social and economic impacts of PFOS are discussed in section 5.2 Summary *of impacts*. The long-term effects of PFOS on human health are uncertain but the possibility of

55 http://www.epa.nsw.gov.au/MediaInformation/williamtown.htm

56 Taylor and Johnson (2016).

57 Dusky Flathead (*Platycephalus fuscus)* fishing restrictions were lifted in April 2017 in response to additional data. Dusky Flathead prefers the benthic zone, at and near the sea bed, and there was a concern it could be exposed to elevated levels of PFAS in sediment. See NSW Chief Scientist & Engineer, 2016 and the April 2017 Williamtown FAQs at http://www.epa.nsw.gov.au/resources/community/170403-Williamtown-FAQs.pdf.

58 http://www.rapidcreek.org.au/Rapid_Creek_Landcare_Group/Report_links_files/Beagley%20report.pdf

59 https://ntepa.nt.gov.au/news/2016/facts-about-pfcs-in-rapid-creek

60 http://www.abc.net.au/news/2016-07-01/kriol-sign-warning-of-contamination-in-nt-creek-'nonsensical'/7543474

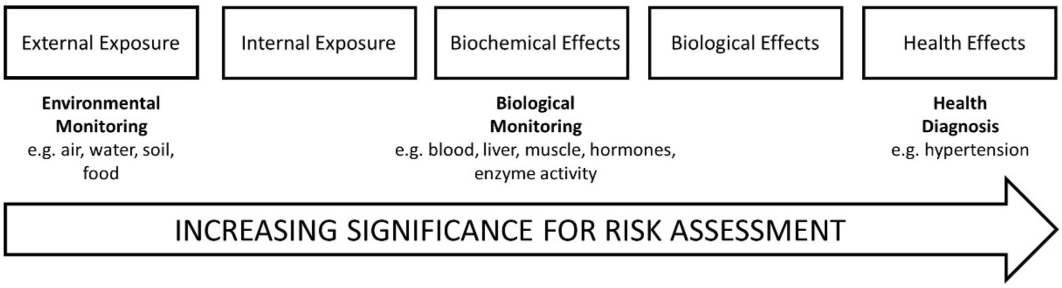
61 http://www.ntnews.com.au/lifestyle/rapid-ludmilla-creeks-toxin-warnings/news-story/6b0fe83702942555e0be14bfcaceb0d6

62 Munksgaard et al (2016).

health effects cannot be excluded based on the evidence available. While animal studies have demonstrated a variety of potential adverse effects, the applicability of these effects to humans is not well established. Research has not yet provided clear relationships between PFOS exposure and human health impacts.

Despite the evidence that PFOS is associated with some health effects, the evidence for a causal relationship between the exposure and these health effects remains inconclusive. This reflects the limitations of individual studies such as small scope and inconsistent findings, as well as differences in the study methodologies. The observed health effects warrant further investigation. Figure 5 illustrates different types of evidence that can contribute to understanding the human health risk from a chemical.

Figure 5. Types of evidence on human health risk from a chemical[63]



Some epidemiological studies suggest potential associations between exposure to PFOS to a number of health effects, including disruption of thyroid hormones; altered blood lipid and uric acid; developmental and reproductive abnormalities; and immune system dysfunction. However, the level of evidence and the biological significance of observed health effects are still unclear.[64] International regulators, including the United States Environmental Protection Agency and European Food Safety Authority noted that the only reasonably consistent and reproducible health effects observed are the increased serum lipid levels (serum total cholesterol and low-density lipoprotein (LDL)), and decreased body weights of offspring.[65]

In summary, drawing on evidence from studies in animals and studies of occupationally exposed workers, it appears that very high levels of PFOS could be linked to biochemical effects. However, there is no clear evidence of resulting health effects in humans.[66] Moreover, PFOS levels in the general population are usually much lower than those found in occupationally exposed workers, and PFOS levels in these workers are in turn much lower than the PFOS levels studied in the laboratory.

Similar to experiences reported in relation to other suspected environmental pollutants, individuals in communities impacted by PFOS contamination may also experience adverse effects on their mental health and wellbeing from increased stress and anxiety. This is in part

63 Adapted from Angerer et al (2007).
64 Victorian Government Department of Health and Human Services (2017).
65 EFSA (2008); ATSDR (2015); US EPA (2016); Barnes et al. (2002); Scammell (2010); Cline et al. (2014); Taylor et al. (2013)
66 NICNAS (2015).

due to the uncertainty around the potential for elevated levels of PFOS to cause adverse health effects. Economic pressures resulting from contamination, such as decreasing property and business values or the loss of income for some landowners and businesses, compound these concerns.[67]

Although there is uncertainty about the causal links between PFOS and impacts on human health, humans are known to be continuously exposed to PFOS through their surrounding environment. The options considered in this RIS aim to minimise the potential impacts of PFOS to humans, including to their health, by limiting future environmental exposure as a precaution.

2.4 What measures are already in place to control PFOS?

The environmental impacts of PFOS use are subject to some regulation by state and territory governments as part of their broader remit to protect the environment from harm. This is covered in more detail in the following section**.** For example, Queensland and South Australia are banning the use of fire fighting foams containing long-chain PFASs (those with a carbon chain length longer than 6 carbon atoms), including PFOS. This action taken to control PFOS reflects concern about its known environmental impacts, particularly on waterways and groundwater, along with a precautionary approach to managing potential risks to human and animal health. Aside from these actions by the state governments of Queensland and South Australia, few restrictions specifically apply to PFOS use in Australia. Box 6 identifies the PFOS-related chemicals currently permitted for use under Commonwealth regulation.

Although there is minimal regulation of PFOS use in Australia, industry has already phased out most previous uses in response to action from manufacturers and emerging concerns from researchers and governments on its risks. Major constraints on further voluntary action include the sometimes-higher cost of alternatives and perceptions regarding poorer or inadequate performance. There is currently no cost signal to the remaining users to drive transition, due to the lack of regulation requiring environmentally appropriate PFOS waste disposal (including destruction, where considered necessary) and that polluters pay for the externality costs of their PFOS use.

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[67] Taylor et al. (2013); US DIBLM (2007).

Box 6. Commonwealth regulation of PFOS-related chemicals[68]

Industrial chemicals

Five salts of perfluorooctane sulfonic acid (PFOS) and PFOSF are in the Australian Inventory of Chemical Substances (AICS).[69] These chemicals are currently permitted for industrial use in Australia. Perfluorooctane sulfonic acid, and any of its salts that are not listed on the AICS, are not prohibited for use in Australia as industrial chemicals. They would however be subject to assessment as new industrial chemicals under NICNAS prior to their introduction. There are a number of other PFOS-related chemicals publicly listed in AICS which may therefore be introduced for industrial use without further assessment. A complete listing is provided in *Attachment A*.[70]

Written approval from the Director of NICNAS must be sought to import or export 12 PFOS-related chemicals as result of their listing under Annex III of the Rotterdam Convention.[71] Export may only occur if permitted by the importing country.

Pesticides

The PFOS-related chemicals considered in this RIS are thought to have never been registered or used as commercial pesticides in Australia, with one exception. Sulfluramid (N-Ethyl perfluorooctane sulfonamide, EtFOSA, CAS No: 4151-50-2), a PFOS-related chemical, was approved for use as a pesticide between 2001 and 2004. No products were registered, however, and therefore it is unlikely to have been widely used in Australia.[72]

PFOS-related chemicals are not prohibited for use as pesticides in Australia but would be considered new pesticides in Australia and thus subject to approval processes by the Australian Pesticides and Veterinary Medicines Authority.

In Australia measures to reduce the importation and use of PFOS have mainly involved a series of non-enforceable recommendations published by NICNAS, and voluntary action by industry.[73, 74]

The NICNAS recommendations include:

[68] In Australia, responsibilities for regulation of chemicals are shared between jurisdictions. The Commonwealth's responsibilities include undertaking risk assessments at a national scale and control at the border through regulation of international imports. The states and territories typically deal with on-ground risk management, control of use, and waste management and disposal.
[69] CAS Nos: 307-35-7, 2795-39-3, 29081-56-9, 29457-72-5, 56773-42-3, and 70225-14-8.
[70] Although many PFOS-related chemicals are not explicitly mentioned in the Stockholm Convention, the listing of PFOSF, an intermediate material in the production of PFOS-related chemicals, covers these chemicals and is likely to have impacted their global production and availability.
[71] CAS Nos: 1691-99-2; 1763-23-1; 24448-09-7; 251099-16-8; 2795-39-3; 29081-56-9; 29457-72-5; 307-35-7, 31506-32-8; 4151-50-2; 56773-42-3; 70225-14-8. See https://www.nicnas.gov.au/about-us/international-obligations/rotterdam-convention for more information.
[72] Rhoads et al (2008) and Nguyen et al (2013) note, however, that EtFOSA can be produced by the degradation of other PFOS-related chemicals such as EtFOSE.
[73] https://www.nicnas.gov.au/news-and-events/Topics-of-interest/subjects/per-and-poly-fluorinated-chemicals-pfcs/pfc-derivatives-and-chemicals-on-which-they-are-based
[74] https://www.nicnas.gov.au/chemical-information/factsheets/chemical-name/perfluorinated-chemicals-pfcs

- PFOS should be restricted to essential uses where less hazardous alternatives are not available.
- PFOS-containing fire fighting foams should only be used in essential applications (i.e. not be used for training purposes).
- Industry should actively seek alternatives and phase out PFOS.
- Existing stocks of PFOS-containing fire fighting foams should be disposed of responsibly on expiry.
- Importers and users of PFOS should be aware of international activities relating to PFOS.
- Importers should ensure that alternative chemicals are less toxic and not persistent in the environment.
- Product labels and Safety Data Sheets should provide up-to-date information on safe use and handling of PFOS.

The production and use of PFOS has mostly ceased in other developed countries. Governments and private companies started to phase out the use of PFOS well before its listing in the Stockholm Convention in 2009. Early actions taken by governments at the international level include:

- The OECD published a hazard assessment in 2002.
- The United States Environment Protection Agency began to regulate PFOS and related chemicals in 2002.
- Sweden filed for a national ban on PFOS in 2005.
- Canada introduced regulations prohibiting the manufacture, use, sale, offer for sale and import of PFOS and PFOS-containing products in 2008.
- In 2006 a European Directive restricted PFOS from sale or use above minimal levels. Further reductions on these levels were set in 2011.

The restrictions on the use of PFOS in countries that have ratified listing under the Stockholm Convention are shown in Box 7. For most countries, the listing of PFOS entered into force in 2010 when many countries were already phasing it out. Since the listing entered into force, many countries have not registered for any uses, suggesting a complete phase out. Of the countries that have registered uses, some have indicated the intention to further phase out these uses.[75]

[75] The ratification status and registration for each country is available on the POPs website (http://chm.pops.int/).

Box 7. List of acceptable purposes and specific exemptions for production and use of PFOS in Annex B of the Stockholm Convention

Acceptable purposes – non-time-limited

Photo-imaging, photo-resist and anti-reflective coatings for semi-conductors, etching agent for compound semi-conductors and ceramic filters, aviation hydraulic fluids, metal plating (hard metal plating) only in closed-loop systems, certain medical devices (such as ethylene tetrafluoroethylene copolymer (ETFE) layers and radio-opaque ETFE production, in-vitro diagnostic medical devices, and CCD colour filters), fire-fighting foam, insect baits for control of leaf-cutting ants from *Atta* spp. and *Acromyrmex* spp.

Specific exemptions - expires after 5 years[76]

Photo masks in the semiconductor and liquid crystal display (LCD) industries, metal plating (hard metal plating, decorative plating), electric and electronic parts for some colour printers and colour copy machines, pesticides for control of red imported fire ants and termites, chemically driven oil production.

Expired exemptions

Carpets, leather and apparel, textiles and upholstery, paper and packaging, coatings and coating additives, rubber and plastics.

2.5 What are the current uses for PFOS?

NICNAS monitored PFOS use in Australia through several national surveys in the early 2000s. The ongoing uses from the latest survey in 2008 included metal plating, aviation hydraulic fluids, photography and photolithography and fire fighting. The surveys confirmed that PFOS was never manufactured in Australia and that it was no longer used for protective coatings on textiles, leather, food packaging, rubber processing, and paint and coating production.

The Department subsequently consulted with industry to profile how Australian industries are using PFOS. The uses, described in more detail below, include fire fighting at major hazard facilities and potentially on ships, as a mist suppressant in metal plating industries, in photographic materials such as X-ray films and potentially in certain medical devices. The reports listed in *Attachment D* and the industry profiles in *Attachment G* provide additional detail.

2.5.1 Consumer products

2.5.1.1 Imports

PFOS is not known to be intentionally present in any consumer products that are currently imported to Australia, although it could appear as a trace contaminant.

[76] Specific exemptions are no longer available for uses in carpets, leather and apparel, textiles and upholstery, paper and packaging, coatings and coating additives, and rubber and plastics.

2.5.1.2 Use

The past use of PFOS in fluorochemical treatment of consumer products appears to have ceased. Product testing of consumer products in use and on sale in 2013 appeared to confirm that fluorochemical treatments no longer commonly use PFOS. The testing detected a range of perfluorinated chemicals in products and product components including carpets, upholstery fabrics, non-stick cookware and children's clothing and accessories. However, it only found PFOS in two leather upholstery fabrics.

Significantly for the Australian phase out, 3M Company, which was once the world's largest producer of PFOS related chemicals, commenced a voluntary phase out of its global PFOS manufacturing operations in 2001. In Australia, 3M phased out the last of its PFOS-based consumer and industrial products, Scotchgard™, by 2002.

2.5.1.3 Alternatives

Alternatives for previous uses of PFOS in consumer products include a range of fluorinated and non-fluorinated substances. For example, many non-stick, stain-resistant, water-repellent and anti-corrosion coatings use poly- and per-fluoroalkyl substances other than PFOS. Manufacturers are also developing alternatives such as plant-based coatings or the selection of different materials to achieve similar outcomes.

2.5.1.4 Waste disposal

Consumer products containing PFOS are generally disposed of through the general waste stream, ending up in recycling or landfill. Research commissioned by the Department shows that most of the PFOS in landfill comes from its historic use in products such as paper, cardboard, carpets and textiles that were disposed to landfill.

Washing displaces a proportion of the PFOS from consumer products. This PFOS ends up in wastewater, where some of it may be removed in biosolids. Rainfall leaching may re-mobilise some of the PFOS from both landfill and biosolids, transporting it into the waste water system or into waterways and eventually to the ocean or groundwater.

Research is underway to investigate the release of PFOS from landfill and from biosolids in order to find ways of reducing these low-level sources of PFOS background contamination.

2.5.2 Metal plating and plastics etching

2.5.2.1 Imports

PFOS is imported for use in the metal plating and plastics etching industries.

2.5.2.2 Use

PFOS forms a film over a fluid surface preventing the release of fluid into the air from bubbling. When used in mist suppressants, it protects workers from the highly toxic chromium VI mist. When used in plastics etching it also doubles as a wetting agent.

2.5.2.3 Alternatives

Consultation with the metal plating industry has found that both non-PFOS products and alternative technologies are available in Australia.

The transition to non-PFOS alternatives is underway but incomplete in the metal plating and plastics etching industries. For some businesses, the perception that alternatives do not perform as well as PFOS has been a barrier to a voluntary transition to non-PFOS products. Analysis undertaken by the Department indicates that the alternative products meet safety and efficacy standards, although the cost is slightly higher because more of the product is needed.

Consultation suggests that of the three commercial suppliers for mist suppressants used in hard chromium plating, one no longer supplies PFOS-containing products.

The costs of transition are detailed further in the impact analysis.

2.5.2.4 Waste disposal

Most states already have requirements for the treatment and / or disposal of metal plating waste to manage its hazardous chromium VI content. There is no requirement, however, that sludge treatment address its PFOS content.

2.5.3 Fire fighting

2.5.3.1 Imports

The import and sale of foam with PFOS as an active ingredient in Australia is thought to have ended in 2003 and there is no indication of industry demand for new imports.

2.5.3.2 Use

Fire fighting foams designed for use against Class B fires, which are fires fuelled by flammable and combustible liquids, often contain fluorinated surfactants. In the past, PFOS was widely used as an active ingredient in these fluorinated foams and is still sometimes present as a trace contaminant. The key users of Class B fire fighting foams are major hazard facilities and other locations where flammable liquids are stored, including airports, aircraft hangars, ports, ships and tug and fire boats, defence facilities, oil and gas refineries, tank farms, electricity generators, chemical manufacturing and storage facilities and mines.

Despite the cessation of imports of PFOS containing products, the use of stocks may remain widespread due to their long shelf life. In 2013 PFOS was estimated to be present in around thirty percent of the fire fighting foam stocks in Australia. There is a possibility, however, that some fire fighting foam users may not be sure whether their foam stocks contain PFOS, for example if the foam was not stored systematically or was purchased second-hand.

The Department of Defence, Airservices Australia, state and territory emergency services and some corporate users have moved away from the use of foams with PFOS as an active ingredient.[77] Although stocks may, in some instances, have been kept for use in an emergency, for research, or for testing emergency equipment, the day-to-day use of these foams is believed to be greatly reduced or eliminated, particularly in training and emergency fire fighting. Advice from state and territory governments and industry suggests that existing stocks may still be used for private sector and possibly volunteer fire fighting.

As at 2013, industry was estimated to hold significant stocks of PFOS-containing fire fighting foam at major hazard facilities such as airport hangars, docks, petrochemical facilities and dangerous goods storage facilities. Fire fighting foam is also widely used in fire suppression systems for high cost infrastructure, such as tunnels and rail maintenance facilities and in mining, particularly for fixed fire fighting systems on large mining vehicles. These major sites have risk management systems in place to prevent and respond to adverse events including environmental pollution. However, there is always a risk of system failure allowing PFOS to escape off-site into receiving environments and creating a potential pathway for human exposure.

The use of PFOS-containing fire fighting foam by shipping in Australian waters is an important consideration for environmental protection. Activities on ships, including fire fighting and training, are governed by the laws of the country in which the ship is registered and the safety and environmental standards set by the International Maritime Organisation.[78]

In addition to working with industry on voluntary changes, state and territory governments are also strengthening regulation to control the use, disposal, destruction and environmental impacts of fire fighting foams containing PFOS. In July 2016, the Queensland Government announced it would ban the future use of fire fighting foams containing PFOS and PFOA, with the responsibility placed on users to minimise environmental impacts from the use of alternate fire fighting methods.[79] South Australia has also announced policies to control the use of PFOS-containing fire fighting foams.[80]

2.5.3.3 Alternatives

The risk of accidental emissions is a major driver of the push by governments and the fire protection industry for a transition away from the use of PFOS-containing foams. If releases of PFOS-containing foams occur in a facility with adequate bunding, the discharge can often be contained and cleaned up. A major release of PFOS to the wider environment can occur, however, if the accident happens in a facility without bunding, or where containment systems are not well maintained or fail, or if the foam is exposed to wind, rain or floodwaters.

Some state and territory governments are therefore working closely with industry to foster a transition to foams that are suitable for use in the Australian environment. Sites likely to impact on sensitive or high conservation value environments, such as surface and groundwater catchments, wetlands, and coastal and marine areas, are a high priority for

[77] See http://www.airservicesaustralia.com/environment/firefightingfoam/use-of-fire-fighting-foam/ and http://www.defence.gov.au/id/pfospfoa/FAQs.asp for information on the transition away from PFOS in Australian Government agencies.
[78] See https://www.amsa.gov.au/environment/index.asp for information on protection of Australia's marine environment from pollution from ships.
[79] https://www.qld.gov.au/environment/pollution/management/investigation-pfas/firefighting-foam/.
[80] https://www.premier.sa.gov.au/index.php/ian-hunters-news-releases/7042-pfos-and-pfoa-to-be-banned-in-south-australia

transition efforts. The owners and managers of these sites are being encouraged to restrict the day-to-day use of PFOS-containing foam and to transition to alternatives, preferably fluorine-free foams, wherever possible.

Numerous users of PFOS-containing foams have already transitioned to non-PFOS products. Some of these alternative products use other PFASs as a surfactant, while others are fluorine-free. All fire fighting foams are harmful if released immediately into the environment (for example, some foams may create biological oxygen demand for a short period), so the selection of alternative products needs to take account of individual site conditions. This includes the ability to minimise the release of foam and firewater in sensitive environments. The choice of foams will depend of what controls need to be met and what management would need to be done for what time period.

2.5.3.4 Waste disposal

State and territory environmental regulation includes provisions to control the disposal of waste that could harm the environment, such as PFOS-containing foam, firewater and contaminated soils that have resulted from fire fighting. These requirements reflect the broader waste management context in each jurisdiction, including the availability, feasibility and affordability of disposal and destruction methods.

Most jurisdictions are considering requirements for PFOS waste disposal. As part of this, governments are working together to develop a broadly consistent approach to prevent fire fighting waste transfer and dumping in jurisdictions with less stringent requirements.

This shift in waste management requirements creates a strong incentive for businesses to review their need to use PFOS, and fluorinated foams more broadly. The onus is on fire fighting foam users to select products that meet their business needs while satisfying regulatory requirements for waste disposal.

For businesses that choose to continue to use PFOS, and are able to do so under regulation, a range of remediation technologies is available designed to immobilise or remove PFOS and other contaminants from waste. This allows safe destruction of the removed material, with the remainder of the waste decontaminated and therefore suitable for disposal in the general waste stream.

Despite the recent increase in regulation of PFOS emissions from fire fighting, the priority in an emergency is always the protection of life and safety. For fire and emergency services, this takes precedence over avoiding PFOS waste generation and emissions. As a result, businesses using PFOS-containing fire fighting foam run a high risk of significant waste disposal and remediation liabilities in the event of an emergency.

2.5.4 Photographic materials

2.5.4.1 Imports

PFOS is imported for use in medical imaging, principally X-ray photography and possibly in replacement charged-coupled device (CCD) units for some older video endoscopes.

2.5.4.2 Use

When used in photographic materials, such as X-ray film, PFOS helps in controlling electrostatic charge, friction and adhesion and repels dirt.

Another historical use of PFOS that may continue is in older medical imaging devices. In 2008, it was estimated that 70 per cent of video endoscopes contained a CCD colour filter with a small amount (150 ng) of PFOS.[81] It is unknown how many of these older machines are still used in Australia. When the CCD colour filter fails, standard practice is for the manufacturer to replace it with another CCD of the same type until the video endoscope reached the end of its useful life.

2.5.4.3 Alternatives

The increased use of replacement technology such as digital imaging is displacing PFOS use. Although this overall trend is expected to continue, there are no known alternatives for the use of PFOS in the older types of X-ray photography. The Stockholm Convention recognises that medical uses in X-ray films are an acceptable use of PFOS.

The use of PFOS-containing CCDs in video endoscopes is being phased out as older devices are decommissioned. Newer devices are PFOS-free.

2.5.4.4 Waste disposal

X-ray films are disposed of after use and most of the PFOS used in X-ray photography remains associated with the developed film. About 40 to 50 per cent of X-ray films are recovered from waste streams and recycled to recover silver. This process involves incineration at over 900 C for up to 24 hours, which is considered likely to destroy the PFOS component, although its efficacy is unconfirmed.

2.5.5 Other potential uses of PFOS for which information is sought

At the time of writing limited information was available on any other current uses of PFOS in Australia. Information is sought on the potential use of PFOS in applications such as aviation hydraulic fluids, medical devices, and any other potential uses (such as in pesticides).

PFOS was previously reported in some aviation hydraulic fluids.[82] However, preliminary research suggests the perfluorinated substance used in the Australian aviation industry is perfluoroethyl cyclohexane sulfonate, which is not a PFOS-related chemical.[83] Information is sought through this consultation process about whether PFOS is still used in aviation hydraulic fluids.

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[81] United Nations Environment Programme Persistent Organic Pollutants Review Committee 2008.

[82] For aviation hydraulic fluids, relevant information includes: the identity of PFOS-related chemicals in current use; estimates of current consumption volumes and stocks in Australia; the costs of using non-PFOS alternatives; and current waste handling and disposal practice.

[83] The molecular formula for the perfluoroethyl cyclohexane sulfonate anion is $C_8F_{15}SO_3$- while the molecular formula for the perfluorooctane sulfonate (PFOS) anion, as identified in the supporting material for the Stockholm Convention listing of PFOS, is $C_8F_{17}SO_3$-. There is no evidence of a mechanism for the perfluoroethyl cyclohexane sulfonate to degrade into PFOS in the environment.

The use of PFOS was also previously reported in certain medical devices.[84] Although it is likely that all or most of these older medical devices will have been phased out in Australia, advice is sought on any remaining use.

No commercial use of PFOS as a pesticide is known to have occurred in Australia. It has been used internationally in pesticides, however, both as an active ingredient and as an additive.[85]

Australia's annual consumption of PFOS has declined with the phase down or cessation of past uses. It is estimated that Australian PFOS consumption declined by around 83 per cent from 2000-01 to 2014-15, from 11.5 tonnes to just over two tonnes. Table 5 provides estimates of consumption by industry or use, as at 2014-15. Fire fighting is the largest current use category for PFOS.

[84] For medical devices, relevant information includes: the number of devices in service that use PFOS-containing CCD colour filters; the expected service life; the frequency of CCD repairs; the cost of replacement; and the current disposal practices or requirements for components containing PFOS.
[85] For example, the lithium salt of PFOS (Lithium perfluorooctane sulfonate, CAS RN 29457-72-5) may in the past have been used as an active constituent or surfactant.

3. WHY IS ACTION ON PFOS NEEDED?

3.1 What does sound management look like?

For chemicals like PFOS that have the potential to cause environmental and human health impacts, sound management requires pricing environmentally sound waste disposal into the cost of chemical use. This approach satisfies the polluter pays principle, a core economic tool for managing the externality costs of environmental contamination. It helps to overcome the limitations and unintended consequences that can arise from the lack of a market mechanism for the efficient pricing of environmental goods.

Sound management also requires regulatory action to minimise the release of chemicals such as PFOS that may pose environmental or human health risks. For non-essential uses, especially those that pose a high risk of dispersing the chemical into the environment, the most efficient option may be to eliminate the use. Another option is moving to a closed-loop system for any remaining uses of the chemical. Although there is no formal definition for closed-loop, the principle of virtual elimination of the chemical in emissions (including waste) is a useful guide to designing a closed-loop system.[86] The globally agreed standards established by the Stockholm Convention provide a robust basis for sound management to protect human health and the environment from POPs such as PFOS.

The Stockholm Convention's requirements for import, export, production, use, environmentally sound waste disposal (including destruction), reclamation and recycling are tailored to address the undesirable environmental characteristics of POPs, and the need to ultimately eliminate them. Accordingly, these requirements represent the globally agreed minimum standard for the sound management of POPs. Box 7 identifies acceptable uses of PFOS and Box 8 provides a summary of the management requirements for PFOS under the Stockholm Convention.

Australia's commitment to the Stockholm Convention reflects the balanced application of the precautionary approach. The precautionary principle of environmental management that has been in place for some time in Australia, states that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.[87]

The precautionary principle is intended to be applied in a balanced way taking into account other considerations to achieve the effective integration of economic, environmental, social and equitable objectives.[88] It mandates caution in the management of POPs, including PFOS, that pose a substantial risk of long-term adverse impacts on society and the environment along with currently unquantifiable but wide-ranging economic costs.

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[86] Environment and Climate Change Canada (2016). Virtual elimination requires that the concentration of a substance in emissions must be below a specified level. This is usually the lowest concentration accurately measurable using routine sampling and analytical methods.
[87] All governments in Australia have agreed to the precautionary principle. (*Intergovernmental Agreement on the Environment,* 1992 available at http://www.environment.gov.au/about-us/esd/publications/intergovernmental-agreement).
[88] Hawke (2009).

In summary, PFOS is internationally recognised as a substance requiring sound management leading to the reduction and ultimate elimination of production and use in order to protect human health and the environment.

Box 8. Summary of Stockholm Convention management general requirements for PFOS (note these are summarised and not the exact wording of the requirements)

Restrict the production and use of PFOS to the permitted specific exemptions or acceptable purposes listed in Annex B and available in the register.

Ensure that PFOS is imported and exported only for the purpose of environmentally sound disposal or for a use listed in Annex B.

Ensure that PFOS is not exported to a State that is not a Party to the Stockholm Convention unless that State has provided an annual certification that specifies that the State is committed to protect human health and the environment and complies with requirements for handling of stockpiles and waste disposal.

Ensure that permitted PFOS use is carried out in a manner that prevents or minimises human exposure and release into the environment.

Identify and manage PFOS stockpiles in an environmentally sound manner that is protective of human health and the environment.

Ensure PFOS-containing wastes are managed in an environmentally sound manner, with high content wastes to be destroyed or irreversibly transformed in the first instance, and disposal operations must not lead to recovery, recycling, reclamation or direct reuse of PFOS.

Endeavour to develop appropriate strategies to identify sites contaminated by PFOS, and undertake any remediation in an environmentally sound manner.

3.2 What are the problems with the existing arrangements?

The existing arrangements to reduce PFOS importation and use in Australia comprise a series of non-enforceable recommendations published by NICNAS from 2002, along with education and advice provided by government and voluntary actions by industry. This low-intervention approach to PFOS use and waste disposal has not achieved sound management throughout the chemical lifecycle. Instead, PFOS continues to be released into the environment. The arrangements do not reflect the polluter pays principle, as the financial costs of using PFOS are much lower than its true externality costs, particularly the cost of environmentally sound waste disposal, including destruction.

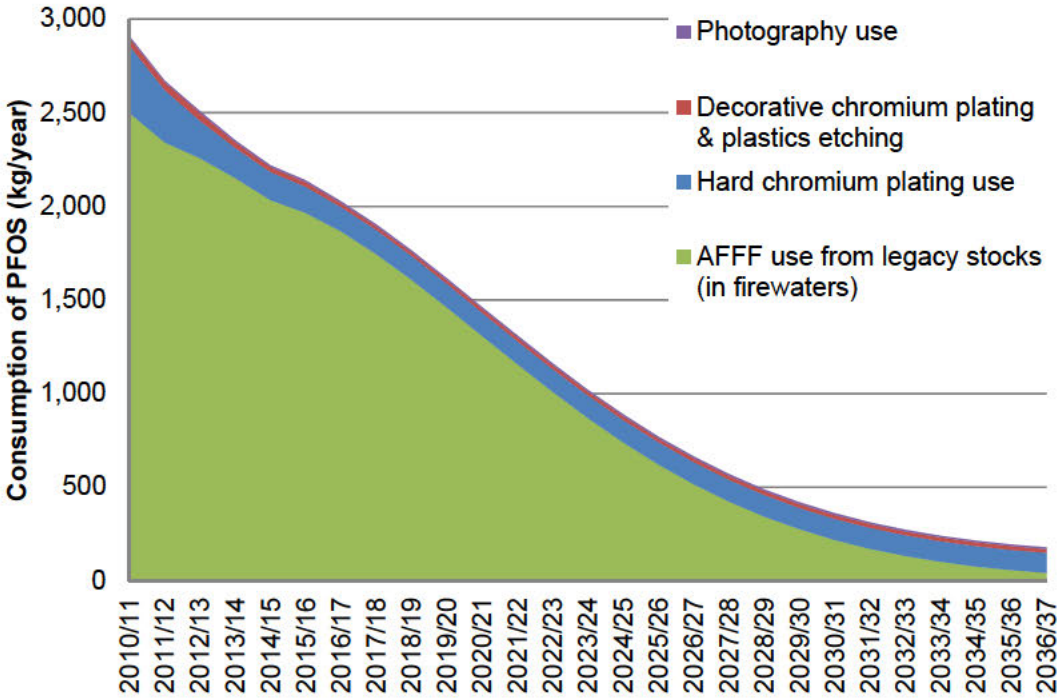
There is no nationally consistent legislation that can ban or restrict the use of an industrial chemical across Australia. If the Government decided to ratify the listing of PFOS under the Stockholm Convention, new controls would be needed to phase down or phase out ongoing PFOS uses and prevent uptake of PFOS use by other industries.

Table 5. Estimated PFOS consumption by industry (2014-15)

PFOS direct use category	2014-15 consumption (kg)
Fire fighting	2034
Hard chromium plating	150
Decorative chromium plating and plastics etching	25
X-ray photography	10
Total	2,219

Table 5 summarises the estimated PFOS consumption by industry in Australia. Figure 6 shows recent trends in PFOS consumption in Australia. It projects future consumption over the next 20 years under the status quo regulatory environment. Fire fighting will continue to account for the vast majority of PFOS emissions to the Australian environment. The projected level of PFOS emissions is inconsistent with protection of the environment and could pose risks to human health.

Figure 6. Trend in estimated consumption of PFOS by industry (2010–11 to 2036–37)



3.2.1 Why don't current practices represent sound management?

Sound management of chemicals requires an integrated approach with specific and appropriate controls covering the whole chemical life cycle, including import and export through to use, monitoring and waste disposal. The lack of appropriate emissions controls during use and appropriate waste disposal requirements for PFOS means that currently the majority of PFOS consumed in Australia is released into the environment as emissions to water or soil (see Table 2). This adds to background levels of PFOS in the environment and poses a risk of creating contaminated sites where the level of PFOS is elevated above guideline values.

There is no PFOS-specific national or state regulation of emissions or use. State and territory controls on waste disposal, including controlled or hazardous waste, are variable and often do not specifically address PFOS.

States and territories have established mechanisms that could help to control PFOS emissions. For example, site licensing could require the on-site capture and treatment of PFOS, or trade waste licensing could limit PFOS entering sewers. However, these mechanisms are not yet widely used to control PFOS and there is as yet no national standard that could be consistently applied to do so. Although states are introducing measures to control fire fighting foams containing PFOS and PFOA, the absence of a coordinated national approach poses a risk to the successful implementation of these measures.

Without controls, wastes entering landfill and sewers are potential point sources of PFOS emissions. Conventional waste management is not readily tailored to meet the requirements for POPs – for example, PFOS does not degrade in landfills or sewage treatment plant processes. Consequently, it may contaminate landfill leachate, effluent and biosolids. These materials are not routinely monitored for PFOS, nor managed to prevent emissions of PFOS. Current waste disposal practices therefore do not constitute sound management for PFOS (see Box 9 for further information).

The management and disposal of PFOS stockpiles is a particular concern. For example, reports suggest that from 2010 to 2013 around 8 tonnes of Australia's fire fighting foam stockpiles were thermally destroyed but the total estimated decline in fire fighting foam stocks was higher. The discrepancy suggests that up to 2 tonnes per year of PFOS could have been emitted into the environment through testing, training, emergency use or, potentially, inappropriate disposal.

Around Australia there are sites contaminated by elevated PFOS levels associated with legacy use of fire fighting foams. Localised contamination may also originate from emissions at industrial sites, notably chromium plating sites, with a history of PFOS use or secondary emissions of PFOS in leachate from legacy wastes already present in landfill. Box 10 provides a case study of the costs resulting from legacy PFOS contamination.

All Australian governments are working to manage the impacts of contaminated sites. The Department has developed PFAS-specific guidance, agreed at the Commonwealth level, consistent with the ASC NEPM standards for investigation of site contamination and is working with state and territory governments on a national plan for managing sites contaminated with PFASs, including PFOS.[89]

[89] Australian Government Department of the Environment and Energy (2016).

Box 9. Requirements for sound management of PFOS waste

The Stockholm Convention requires appropriate management of wastes containing PFOS. Waste can be disposed of in an environmentally sound manner where the POP content is low. For PFOS, the provisional low content limit for waste disposal is 50 mg/kg.

Consistent with agreed international approaches, if waste material contains above 50 mg/kg PFOS the waste must be treated using a technique that will destroy or irreversibly transform the PFOS. For example, techniques such as plasma arc or high temperature incineration (above 1100°C) are already agreed technologies for destruction. When destruction or irreversible transformation does not represent the environmentally preferable option due to environmental or human health impacts, then the PFOS waste could:

- be immobilised; or
- be disposed of in highly secure and specially engineered landfill or, when commercially available in Australia, in permanent storage in underground mines and formations, consistent with Section IV.G.3 of the Basel Convention's general technical guidelines on the environmentally sound management of waste consisting of, containing or contaminated with persistent organic pollutants.[90]

It is noted that Section IV.G.3 of the Basel Convention's general technical guidelines on the environmentally sound management of waste consisting of, containing or contaminated with persistent organic pollutants also applies to construction and demolition wastes such as mixtures of, or separate fractions of, concrete, bricks, tiles and ceramics.

More general landfilling may not be an environmentally sound method of PFOS waste disposal. Depending on site-specific engineering and leachate management practices, PFOS may contaminate groundwater, or be discharged to sewers – contributing to the PFOS burden in effluent entering surface waters and in biosolids applied to land.

Discharge of PFOS liquid wastes to sewers or stormwater is not considered environmentally sound disposal as PFOS is not removed or destroyed during conventional wastewater treatment. In a sewage treatment plant PFOS partitions between the effluent and the biosolids. Effluent is typically released to surface waters, evaporated, used for irrigation or recycled. Biosolids are generally applied to land, or may be stockpiled if not suitable for re-use.

Monitoring has confirmed PFOS is present in Australian landfill leachate (up to 2700 ng/L), effluent (up to 240 ng/L) and biosolids (up to 102 ng/g).[91]

Additional actions to meet the Stockholm Convention management standards for existing contaminated sites are not proposed at this stage, in light of the regulatory and policy activity already underway. This RIS therefore focuses on preventing additional contamination to avoid future costs to both industry and government and other impacts to the community and the environment.

[90] United Nations Environment Program (2015).
[91] Gallen et al (2016).

Box 10. Case study – Costs associated with PFOS contamination

The Government provided financial assistance to eligible fishers and businesses affected by the commercial fishing closures from 4 September 2015 to 1 October 2016 (and to April 2017 for Dusky Flathead) due to PFOS and PFOA contamination at Williamtown. Payments for individuals were made at the applicable Newstart or Youth Allowance rate of up to $523 per fortnight, with up to $25,000 for businesses.[92, 93]

Families who relied on fishing near Williamtown estimate losses of up to $100,000 over the closure period.[94]

The NSW Government provided a support package for the Williamtown community worth $10 million. This included the connection of 190 properties to town water supply at an estimated cost of $4 million.[95]

Government health initiatives to support affected communities at Williamtown and Oakey include an epidemiological study, voluntary blood study, additional dedicated mental health and counselling services. The Australian Government's Chief Medical Officer has also published health based guidance values (HBGVs) for PFAS to guide site investigations in Australia.[96] These measures are part of a $55.0 million package announced by the Government in 2016.[97] A water treatment plant will be installed at a cost of $9.0 million to ensure that PFOS and PFOA levels in water leaving Lake Cochran at RAAF Base Williamtown are below the adopted drinking water screening criteria.[98]

Unknown costs include: site investigations (and associated human health and environmental risk assessments), biota and environmental monitoring, site remediation, ongoing site monitoring and management, lost agricultural productivity from land or water contamination, loss of income to tourism industries, reputational damage for fisheries leading to loss of sales, land devaluation, and legal liabilities (see Box 12).

The Government is also providing $12.5 million over four years from 2017-18 to establish a National Research Program to study the potential effects of PFAS exposure on human health.

3.2.2 What are the international considerations?

In the absence of government action, there is potential for interruptions to the supply of PFOS imports, particularly for metal plating. If Australia does not ratify PFOS, annual certification will still be required to secure imports from the main suppliers, Germany and

92 http://www.defence.gov.au/id/_Master/docs/Williamtown/MediaReleaseFederalGovernmentExtendsItsSupportToCommercialFishersInTilligerryCreekAndFullertonCove.pdf

93 http://www.defence.gov.au/id/_Master/docs/Williamtown/MediaRelease-FinancialAssistanceForCommercialFishers.pdf

94 http://www.news.com.au/national/breaking-news/fishing-bans-near-williamtown-base-lifted/news-story/1cd42a09b7a66950f71959c95078ab68

95 http://www.portstephensexaminer.com.au/story/3605014/town-water-connection-for-affected-residents/

96 http://www.health.gov.au/internet/main/publishing.nsf/Content/ohp-pfas.htm

97 http://www.abc.net.au/news/2016-06-14/federal-coalition-announces-package-to-deal-with-contamination/7507518

98 http://www.minister.defence.gov.au/2016/05/06/water-treatment-plant-for-lake-cochran-raaf-base-williamtown/

China. Further information on certification requirements under the Stockholm Convention is provided in Box 11.

The Government is unable to provide certification under current arrangements. The absence of a comprehensive and consistent national approach to PFOS management means that it is not possible to provide the evidence required for certification. The need to certify future imports could cause significant supply delays and costs for industry while seeking out new suppliers or testing and transitioning to alternatives. This creates uncertainty for businesses reliant on imported PFOS.

Box 11. Certification under the Stockholm Convention

Why is certification needed?

Australia's main suppliers of PFOS, Germany and China, have both ratified the listing of PFOS. A country that has ratified the listing of PFOS under the Stockholm Convention cannot export PFOS to countries that have not ratified the listing of PFOS unless the importing country provides annual certification to the exporting country.

What is certification?

The Government would provide certification to an exporting country on request. Under the Stockholm Convention certification needs to:

- specify the intended use of the chemical and include a statement that Australia is committed to:
  - protecting human health and the environment by taking the necessary measures to minimise or prevent releases
  - complying with the provisions under the Stockholm Convention relating to managing stockpiles and waste.
- include supporting documentation such as legislation, regulation, administrative or policy guidelines that give this effect.

Without controls on imports of PFOS, the potential exists for international companies trading in PFOS-containing products to target Australia if these products are no longer marketable to other countries that have already phased out or regulate its use. Australia could therefore become one of the few countries where the supply of PFOS-related chemicals, articles, and manufactured products remains legal and, potentially, a dumping ground for unwanted PFOS-containing products. Despite the increased awareness of contamination impacts from PFOS use, especially in fire fighting foams, existing controls are not sufficient to ensure safe use and disposal and destruction, where appropriate.

The key risk is marketing of PFOS-containing products in Australia to new users with potentially persuasive advertising. The continuing use of PFOS or PFOS containing products without regulation exposes Australia to the risk of rising health and environmental impacts in the context of stringent regulation of PFOS in other countries.

There is also a risk of unquantified costs relating to damage to Australia's international reputation in relation to ratifying and implementing global treaties. Given the high level of interest and activity relating to PFOS in international fora such as the OECD, this could also affect Australia's standing in international markets. Most of Australia's key trading partners, including China, Japan, Korea, the UK and Germany, have ratified the Stockholm Convention listing of PFOS.

A key asset for Australia internationally is its clean, environmentally friendly brand. Australia earns more than $40 billion annually from food exports. Regulation of PFOS would prevent future emissions of PFOS into the Australian environment and consequently its movement into the food chain.[99] By minimising PFOS emissions, and any potential for increased levels in food, wine and other export products into the future, regulation would therefore support Australia's primary producers and food processors to market their products on the international market.

3.3 What are the objectives of action?

The options explored in this RIS address the main objective of protecting society and the environment from the impacts of PFOS exposure. Complementary outcomes of action are likely to include improved certainty for business and avoided contamination.

The most effective way to minimise potential risks to humans and the environment is through minimising future exposure to PFOS. This requires a conservative approach based on phasing out low-value and inessential uses of PFOS and controlling emissions from any remaining essential uses. States and territories are already taking action in this regard. Regulation at the national level would support the efforts of states and territories to prevent future emissions from occurring, while ensuring the ongoing availability of PFOS for essential uses in controlled conditions.

The global transition away from PFOS use, associated with the listing of PFOS under the Stockholm Convention, is reflected in the trend of declining PFOS use in Australia. For industries that have not yet already transitioned to alternatives, a regulatory approach may provide the necessary incentive to do so. A consistent national regulatory approach would also ensure the environmentally sound disposal of any stockpiles of unwanted PFOS.

Analysis by the Department modelled the lifecycle and material flows of PFOS into the environment to determine current exposure pathways and the most efficient and effective points for regulatory intervention. The analysis suggested that reducing future emissions from fire fighting use would have the greatest impact in reducing PFOS releases. Section 3.4 *What are the potential intervention* points? outlines actions to address this and other pathways for the release of PFOS.

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[99] The Food Regulation Standing Committee, in its statement on PFAS and the general food supply, concluded that: "a dietary exposure assessment, literature review, and the 24th Australian Total Diet Study conducted by FSANZ (in which two PFAS compounds, that is, PFOS and PFOA, were screened) indicated that the risk posed by these chemicals to consumers in the general population is likely to be very low" (http://foodregulation.gov.au/internet/fr/publishing.nsf/Content/pfas).

3.4 What are the potential intervention points?

3.4.1 Introduction

The earliest possible intervention point to control future PFOS emissions is the introduction of PFOS to Australia through manufacture or import. Australia does not currently manufacture PFOS although there is no control preventing this.

3.4.2 Use and waste disposal

Each major PFOS use is a potential source of emissions. These emissions could be reduced by either preventing use or allowing ongoing uses with controls to capture and manage the PFOS content in the resulting waste streams.

The metal plating industry is the source of two major PFOS-containing waste streams. While the hard chromium plating process is thought to destroy almost half of the PFOS used, the rest of the PFOS largely remains in treatment sludges stored onsite and currently disposed to landfill. In decorative chromium plating, around 90 per cent of the PFOS used is disposed to sewers as liquid waste, albeit at low concentrations.

For photography, the main identified waste streams are photographic materials (films, papers and plates) going to landfill, and films destroyed in the silver recovery process. Because most emissions from this use are a legacy of historical widespread use in photography applications, with old photographic materials now being disposed, measures that target waste would be more effective than controls on future use.

The PFOS used in fire fighting is believed to come from existing stocks only. Controls on imports alone would therefore not reduce ongoing emissions from fire fighting. PFOS use and disposal controls would also be important to reduce emissions for this use. Options include controls to reduce the initial use of PFOS-containing fire fighting foam, or to require the collection, disposal and, where necessary, destruction of the resultant PFOS-containing firewater and other contaminated wastewater.

Historically, due to the absence of effective pollution control measures most PFOS consumed in fire fighting was likely to end up in the environment, whether in surface waters, groundwater, or soil. Intervention this late in the chemical lifecycle to prevent or clean up emissions into the environment is costly and often ineffective. Table 6 illustrates the increase in cost to treat and dispose of PFOS once it is used in fire fighting, as compared to PFOS in unused fire fighting foam concentrate. The most cost-effective intervention point is therefore to destroy PFOS-based fire fighting foam concentrate prior to its use.

Table 6. Cost to destroy PFOS in fire fighting materials

Materials	Activities	Cost ($ per kg PFOS)
fire fighting foam concentrate	Collection, transport and destruction in cement kiln	410
Firewater	Collection, transport, treatment (reverse osmosis and activated carbon), disposal of residual material and destruction of PFOS content by high temperature incineration	6,260
Contaminated soil	Site survey, excavation and transport, testing, storage, treatment (blending, drying, thermal desorption), recovery and disposal of clean material, and destruction of PFOS content by high temperature incineration	79,500

3.4.3 Waste infrastructure

Waste infrastructure, such as sewage treatment plants and landfills, is a potential secondary source of PFOS emissions. PFOS may leach out of solid waste (such as PFOS-treated carpets) or from biosolids and sludges and potentially enter groundwater or be discharged to sewers.

Management of landfill leachate is therefore a key area for intervention. Controls that limit new sources of PFOS from entering landfill without appropriate leachate management systems would serve to minimise releases from future wastes. However, this would not address PFOS from legacy wastes already in landfills that lack leachate collection systems or discharge leachate to sewers. Determining the extent of PFOS leaching from legacy wastes in landfills, and thus the most appropriate interventions, would require further monitoring.

The PFOS entering sewage treatment plants may come from landfill leachate, trade wastes or stormwater from contaminated sites entering sewers. Domestic sewerage is not likely to be a significant source of PFOS in influent due to the discontinuation of PFOS use in consumer applications. However, the relative contribution of these (or other potential) sources to the total PFOS measured in sewage treatment plant influent is unknown.

If contaminated site drainage is adequately managed and waste controls are strengthened for the current industrial uses of PFOS, the amount of PFOS in influent may decline. This outcome would negate the need for ongoing biosolids monitoring and management. It would require monitoring to identify changes in influent, effluent and biosolid PFOS levels following the introduction of controls.

In the absence of biosolids guideline levels for PFOS, the reuse of biosolids on agricultural soil could be an ongoing source of PFOS exposure for people who consume food produced on the amended soils and for the wider environment. Some government intervention is likely to be required to encourage appropriate management of the PFOS content in biosolids. This intervention could entail including PFOS in current biosolids monitoring programs, setting guideline levels for PFOS in biosolids and determining appropriate disposal methods for biosolids that do not meet the guidelines. It may be more efficient to focus on reducing

PFOS entering waste infrastructure, for example by placing conditions on PFOS use that prevent its discharge to sewers. However, this approach may not be possible in practice and would depend on whether sources can be identified.

3.4.4 Remediation

As outlined earlier in this RIS, it is very difficult to reverse the adverse effects of PFOS once released to the environment due to its persistence and tendency to bioaccumulate. Clean-up may be possible for localised areas of higher PFOS concentration but most PFOS disperses in the environment and cannot be targeted for clean-up. Therefore, intervention after PFOS is released is unlikely to significantly reduce environmental exposure or be cost effective.

3.5 Why is government intervention needed?

The market is not currently delivering efficient, effective and equitable outcomes in relation to the management of PFOS. The current patterns of PFOS use in Australia are imposing high externality costs on communities and the environment. Although the businesses and other organisations using PFOS do experience benefits arising from its unique chemical properties, the evidence shows that substitutes are available for most of these uses.

In the absence of government intervention, emissions of PFOS into the Australian environment are projected to continue over the next 20 years. Although the amount of PFOS used in Australia is declining each year, the situation does not meet the requirements for appropriate management under the Stockholm Convention. Over the next 20 years, this base case of no new government action on PFOS is projected to result in the emission of over 25 tonnes of PFOS to the environment. The PFOS emitted during this period will persist in the environment adding to existing environmental loads and posing a risk to the environment and potentially to human health.

As outlined above, there is an opportunity for effective government intervention to reduce PFOS emissions to the environment immediately, by improving the minimal existing controls on PFOS releases from use and wastes. The Department's material flow analysis based on industry profiling identifies potential intervention points to prevent or minimise environmental emissions of PFOS. The range of possible actions include reducing PFOS introduction (including import), phasing out uses, improving management of PFOS releases where there is ongoing use, and improving management of PFOS emissions from its various waste streams.

Co-regulatory or voluntary options are not appropriate for implementation of international treaties where full compliance by parties is necessary. Australia does not directly and automatically incorporate treaties that it has joined into Australian law. Enabling legislation at either Commonwealth, State or Territory level will be needed for Australia to be legally compliant with Stockholm Convention management requirements for PFOS. Action on treaty matters needs to be led by the Government and not by industry or community organisations.

The Commonwealth is best placed to act on the aspects of PFOS control that affect all of Australia. It has responsibility under the Constitution for matters of external affairs, such as treaty actions. States and territories may be better placed to implement matters that do not fall within the Commonwealth's traditional areas of responsibility. This division of responsibilities would require national coordination by the Government to ensure consistent implementation that both achieves the objectives of this RIS and meets international obligations.

4. WHAT ARE AUSTRALIA'S OPTIONS FOR THE PHASE OUT OF PFOS?

The Department has developed the following options for the phase out of PFOS emissions to protect the environment and human health, with reference to the globally accepted standards established by the Stockholm Convention and the evidence on what is feasible in the Australian context.

Importantly, all three options for government action would rely on a partnership approach to implementation. The Australian Government would work with state and territory governments to implement the proposed measures in consultation with industry and the community.

Table 7 summarises the options while Table 8 summarises the measures required to implement each option. The Department welcomes feedback on these options and measures, including information about actions that are planned or already underway in specific jurisdictions or industries to phase out PFOS emissions.[100]

All of the options for government action will protect human health and the environment by reducing PFOS emissions, although the degree to which emissions decline will depend on the actions taken under each option. For more detail, see the sections below describing each option.

Table 7. Summary of the options for phasing out PFOS

Option	Summary
Option 1: No new policy intervention	Uncosted baseline. Australia would not take any new actions to phase out PFOS use or reduce emissions.
Option 2: Do not ratify, but implement certification requirements	Estimated cost: $100.80 million. Australia would implement controls on PFOS emissions and waste disposal to meet the Stockholm Convention certification standards.[101] This would allow the Government to provide certification for PFOS to countries that have ratified the Stockholm Convention listing of PFOS, so that PFOS imports from these countries can continue. This option would reduce PFOS emissions as a result of strengthened management practices but would not prevent the risk of accidental releases. Subject to consultation, this change could be implemented through amendments to existing legislation and policy. Aside from improved waste management, no restrictions would apply to current PFOS uses and Australia would not ratify the Stockholm convention listing of PFOS.

[100] For information about the consultation process, the information being requested, and how to make a submission, see Section 7.

[101] The Stockholm Convention sets out the certification requirements in Article 3(b)(iii), including committing to protect human health and the environment by minimising or preventing releases and complying with waste disposal requirements set out in Article 6.1.

Option	Summary
Option 3: Ratify and register permitted uses	Estimated cost: $100.53 million. In addition to implementing the PFOS waste disposal controls outlined in Option 2, Australia would implement controls on PFOS import, export, manufacture and use to meet Stockholm Convention standards.[102] Australia would ratify the Stockholm Convention listing of PFOS and register for the continued use of PFOS for fire fighting, hard chromium plating, photo-imaging (X-ray photography) and certain medical devices (CCD colour filters) and for a five-year phase out of decorative chromium plating and plastics etching.[103] This option would reduce PFOS emissions as a result of strengthened management practices but would not prevent the risk of accidental releases. Subject to consultation, these changes could be implemented through new legislation or amendments to existing legislation and policy.
Option 4: Ratify and phase out all non-essential uses	Estimated cost: $38.75 million In addition to implementing the PFOS controls outlined in Option 3 to meet Stockholm Convention standards, Australia would ratify the Stockholm Convention listing of PFOS and register for the continued use of PFOS for photo-imaging (X--ray photography) and certain medical devices (CCD colour filters). All other uses of PFOS would be banned. This option would effectively prevent the ongoing risk of accidental releases of PFOS by requiring its withdrawal from use. Subject to consultation, these changes would be implemented through new legislation or amendments to existing legislation and policy.

[102] Articles 3, 4, 5 and 6 of the Stockholm Convention set out the key requirements for implementation.

[103] The continued uses proposed for Option 3 are broadly consistent with the uses already registered by several other OECD countries, noting that for the hard chromium plating industry continued PFOS use would be allowed only in closed loop systems. For details see http://chm.pops.int/Implementation/Exemptions/AcceptablePurposesPFOSandPFOSF/tabid/794/Default.aspx

Table 8. Summary of the measures under each option for phasing out PFOS

Measure		Option 1	Option 2	Option 3	Option 4
Import and export controls		No	No	Restrict	Restrict
Manufacture controls		No	No	Restrict	Restrict
Certification		No	Yes	No	No
Licensing		No	No	Yes	Yes
Use restriction	Hard Chromium Plating	No	No	Closed-loop only	Ban
	Decorative chromium plating	No	No	Ban after 5 yrs	Ban
	Plastics etching	No	No	Ban after 5 yrs	Ban
	Fire fighting	No	No	No	Ban
	X-ray photography	No	No	No	No
	Replacement parts for older medical devices	No	No	No	No
	Aviation hydraulic fluids*	No	No	Ban	Ban
	Textiles, clothing, leather*	No	No	Ban	Ban
	Mining*	No	No	Ban	Ban
	Paper and paper board*	No	No	Ban	Ban
Product trials – transition to non-PFOS alternatives	Hard chromium plating	No	No	Yes	Yes
	Decorative chromium plating	No	No	Yes	Yes
	Plastics etching	No	No	Yes	Yes
Improved waste management	Hard chromium plating - sludge	No	Yes	Yes	N/A
	Fire fighting uses – firewater and soil	No	Yes	Yes	N/A
	Fire fighting uses – disposal of existing stocks	No	Yes	Yes	N/A
	Photographic materials - film	No	No	No	Yes
	Water utilities - biosolids	No	Yes	Yes	Yes
	Landfill - leachate	No	Yes	Yes	Yes
Industry awareness, education and training	Alternatives	Yes	Yes	Yes	Yes
	Certification requirements	No	Yes	No	No
	Ratification requirements	No	No	Yes	Yes

*It is assumed there is no current use of PFOS in these in industries, but there is no restriction under Options 1 and 2.

4.1 Option 1: No new policy intervention

Under Option 1, the Government would not take any additional action to reduce PFOS emissions or phase out its use.

All current uses would continue without new regulatory controls at the national level. The Government would continue to monitor international developments under the Stockholm Convention, particularly in relation to PFOS production, use, standards and alternatives. Existing non-regulatory measures would also continue, such as developing information and resources for industry to facilitate the uptake of alternatives.

This option presents a range of risks:

- Use of PFOS would continue, including the use of existing stockpiles.[104]
- PFOS emissions, waste disposal and destruction would not be controlled.
- The listing of PFOS under the Stockholm Convention would not be ratified.
- The Government would be unable to provide certification of PFOS to exporting countries that have ratified the listing of PFOS under the Stockholm Convention.
- Future PFOS imports may stop due to the lack of certification, affecting businesses that continue to import PFOS such as chrome platers.
- Industry would be exposed to costs and uncertainty due to continuing inconsistency across Australian jurisdictions in the management of PFOS.
- Further contamination could occur because of ongoing PFOS use, potentially increasing future costs such as legal liabilities for industry and governments.

Option 1 assumes that the current trends in use, consumption and emissions continue. It therefore assumes a reduction in annual emissions of PFOS, noting this is not guaranteed in the absence of regulation.

The overall trend for decreasing emissions under the base case is strongly influenced by the assumed trend of decline in PFOS consumption for fire fighting, as the most significant source of PFOS emissions in Australia. It is assumed that no new stocks of PFOS will be imported for this use. Annual releases from fire fighting would therefore decrease over time, as existing stocks are consumed or destroyed and alternatives are adopted in fire fighting. However, this option would not prohibit future imports.

New uses of PFOS, or those already phased out, are considered unlikely to emerge in Australia. This reflects the limitation on exports from countries that have ratified the Stockholm Convention listing of PFOS, such that these countries are only able to export PFOS for uses that are permitted under the Stockholm Convention. However, Option 1 would not specifically prevent the emergence of new uses.

Although this option is the base case for the cost benefit analysis, it is not a feasible option to achieve the policy objectives for two main reasons. Firstly, it creates ongoing uncertainty for businesses that rely on PFOS imports. Secondly, it would not meet international standards for environmentally sound management. In the absence of controls on waste, it would not reduce emissions from use of existing stocks

In summary, Option 1 would not address the need to protect human health and the environment.

4.2 Option 2: Do not ratify, but implement certification requirements

Under Option 2, Australia would not ratify the PFOS listing but would improve PFOS management to meet certification requirements under the Stockholm Convention, principally

[104] States and territories are increasingly restricting the use of PFOS-containing fire fighting foam – for example the restrictions introduced by Queensland in July 2016.

in relation to use and waste disposal. Businesses that import PFOS-containing products and articles would only be able to do so once the Government has provided certification for the intended use.

All current uses of PFOS could continue under this option and certification would ensure continued supply of PFOS to industry.

Table 9 summarises the measures applying under Option 2.

Table 9. Measures under Option 2

Use	Stockholm category	Controls
Certification provided for the following uses		
X-ray photography	Photo-imaging	Imports and manufacture permitted but controlled No change to existing industry recycling program
Hard chromium plating	Metal plating	Imports and manufacture permitted but controlled Environmentally sound waste disposal Requirement to destroy PFOS-containing wastes i.e. sludges
Decorative chromium plating and plastics etching	Metal plating (decorative plating)	Imports and manufacture permitted but controlled Environmentally sound waste disposal
Replacement parts (e.g. CCDs)	Certain medical devices	Imports and manufacture permitted but controlled
Fire fighting	Fire fighting foam	Imports and manufacture permitted but controlled Environmentally sound waste disposal (i.e. unwanted fire fighting foam concentrate stocks, firewater, contaminated soil)
No certification provided for any other uses		
Examples include (but not limited to) treatments for paper, textiles, carpet, clothing, leather, mining, aviation hydraulic fluids		Imports and manufacture end except for the purpose of environmentally sound disposal

The Government would provide certification in response to a direct request from the exporting country. Certification involves providing documentation of the measures taken to minimise or prevent PFOS releases from use and wastes. These measures could be a combination of regulatory measures and non-regulatory supporting measures, such as national standards or policies implemented by each jurisdiction to control releases and appropriately manage PFOS-containing wastes, including biosolids.

Certification would require additional controls on wastes generated during PFOS use compared to the base case. For fire fighting, users of PFOS-containing fire fighting foam would be expected to contain and safely treat or destroy all firewater and other PFOS-containing waste.[105] The hard chromium plating industry would be expected to capture and destroy PFOS-containing wastes, particularly sludges. As decorative chromium plating produces wastes with low levels of PFOS, a requirement to treat these wastes is unlikely.[106] Additional controls are also unlikely for X-ray photography. Most of the PFOS in X-rays remains associated with the developed film and, once it becomes a waste, is expected to be destroyed in silver recovery processes under the existing industry recycling program.

Improved management of biosolids would be required for certification so that Australia can demonstrate that its PFOS-containing wastes, including biosolids, are disposed of appropriately and are not reused. It is expected that biosolids guideline levels would be developed and agreed nationally, and implemented by each jurisdiction. Implementation would entail diversion of biosolids with PFOS exceeding guideline levels from reuse, and destruction of biosolids where PFOS exceeds the low content limit.

Monitoring on a co-regulatory or non-regulatory basis would be implemented for landfill leachate and biosolids. This could involve landfills and water utilities providing samples to governments for analysis in accordance with a jointly developed monitoring plan. The monitoring would initially be conducted for five years to establish the extent to which upstream controls of PFOS sources have reduced the amount of PFOS entering and being emitted from waste infrastructure. This program would then inform appropriate intervention for management action to minimise releases from waste infrastructure.[107]

The introduction of new requirements for all industries, including the water utilities industry, would be supported by non-regulatory education and training packages to maximise the effectiveness of the measures and compliance rates. The Australian government would continue to share information with industry to facilitate their uptake of alternatives.

The trends in PFOS use and consumption for Option 2 are expected to be the same as for Option 1. However, this option is expected to significantly reduce PFOS emissions into the environment due to its new controls on releases and waste, particularly the collection and more appropriate disposal of firewaters and biosolids.

4.3 Option 3: Ratify and register permitted uses

Under Option 3, Australia would ratify the listing of PFOS and register for the acceptable purposes and specific exemptions under the Stockholm Convention that are relevant to Australia.

Ratification requirements are similar to those for certification in terms of minimising PFOS releases from use and appropriately disposing of PFOS-containing wastes. Therefore, many

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[105] As explained above, the cost benefit analysis assumes that appropriate drainage control measures are already in place at each site where PFOS-containing fire fighting foam is used.
[106] See Box 8 for details.
[107] For example, monitoring studies may indicate a need for ongoing monitoring and / or improvement to landfill leachate management practices, or preclude the need for ongoing biosolids management. The potential outcomes of the monitoring program are speculative and are not considered in the impact analysis, with the exception that major infrastructure development to increase biosolids destruction capacity would be subject to a demonstrated ongoing need and is thus assumed to be delayed by five years.

of the measures under Option 3 are similar to those in Option 2. Although no immediate bans would occur, some uses would be phased out within five years.

Improved management of PFOS use and wastes, to minimise environmental emissions, would be required to meet Australia's obligations under the Stockholm Convention. Controls on import, export and manufacture would also be introduced. Legislation is likely to be required to ensure that measures are appropriate and adapted to the legal status of Australia's obligations following ratification.

Table 10 summarises the measures applying under Option 3.

Table 10. Measures under Option 3

Use	Stockholm category	Controls
Registration for acceptable purposes for ongoing uses		
X-ray photography	Photo-imaging	Imports and manufacture permitted but controlled Users licensed No change to existing recycling program
Hard chromium plating (closed-loop)	Metal plating (hard metal plating) only in closed-loop	Imports and manufacture permitted but controlled Users licensed Requirement to destroy PFOS-containing wastes i.e. sludges
Replacement parts (e.g. CCDs)	Certain medical devices	Imports and manufacture permitted but controlled
Fire fighting	Fire fighting foam	Imports and manufacture permitted but controlled Requirement to destroy PFOS-containing wastes (i.e. unwanted fire fighting foam concentrate stocks, firewater, contaminated soil)
Registration for specific exemption for uses permitted for 5 years		
Hard chromium plating - open loop	Metal plating (hard metal plating)	Imports and manufacture permitted but controlled for first 5 years, then banned Use is licensed in first 5 years, then banned Requirement to improve processes and capture and destroy PFOS-containing wastes i.e. sludges By year 5 users either - Transition to a non-PFOS alternative - Introduce closed-loop system Environmentally sound disposal required
Decorative chromium plating and plastics etching	Metal plating (decorative plating)	Imports and manufacture permitted but controlled for first 5 years, then banned Use is licensed in first 5 years, then banned By year 5 users transition to a non-PFOS alternative Environmentally sound disposal required
No registration for any other uses		

Use	Stockholm category	Controls
	Examples include (but not limited to) treatments for paper, textiles, carpet, clothing, leather, mining, aviation hydraulic fluids	Imports and manufacture banned except for the purpose of environmentally sound disposal Use banned

This option is expected to lead to a gradual reduction in existing PFOS stocks, particularly fire fighting foams, through continued use while at the same time minimising environmental emissions of PFOS through more appropriate management.

PFOS uses in fire fighting foam, hard chromium plating (only for closed-loop systems) and medical imaging could continue indefinitely as these are acceptable purposes under the Stockholm Convention. However, Government would work with these industries to shift towards appropriate waste management and destruction and adoption of the best available techniques to minimise their overall PFOS emissions. Governments would also continue to share information with industry to facilitate their transition to alternatives even where ongoing use is permitted.

The use of PFOS in decorative chromium plating, plastics etching and open-loop hard chromium plating would be phased out over five years.[108] Businesses in the hard chromium plating industry currently using open-loop systems may opt to change to closed-loop systems rather than transitioning to non-PFOS alternatives.

No information was available to indicate current PFOS use in aviation hydraulic fluids. In the absence of further information, Australia would not register this acceptable purpose and this use of PFOS would be banned. The import, manufacture and use of PFOS for any other purposes (i.e. its historic uses as a protective agent for carpets, upholstery and leather products, etc.) would be banned in Australia.

As with Options 1 and 2, the impact analysis for Option 3 assumes that any continuing PFOS use in fire fighting is sourced from existing stocks only. It would, however, not restrict further imports for this use and hence Australia could become one of the few countries where the supply of PFOS-related chemicals, articles, and manufactured products remains legal and, potentially, a dumping ground for stocks from other countries that no longer permit this use.

Option 3 is not expected to change trends in PFOS use and consumption for fire fighting, photo-imaging and certain medical devices. The controls introduced for these ongoing uses are, however, expected to significantly reduce emissions compared to the base case, with the emissions for these uses projected to be the same as for Option 2.

[108] In accordance with Article 4(4).

However, Option 3 is expected to reduce total emissions overall compared with Option 2 because:

- It is assumed that the hard chromium plating industry would increase its uptake of closed-loop systems and of alternatives to PFOS, reducing overall consumption and emissions for this use compared with Option 2.

- The phase out of PFOS in decorative chromium plating and plastics etching would further reduce total emissions compared with Option 2.

Thus, Option 3 goes further than Option 2 in addressing the objective of protecting human health and the environment from PFOS exposure.

4.4 Option 4: Ratify and phase out all non-essential uses

Under Option 4, Australia would ratify the Stockholm Convention listing of PFOS, and allow ongoing PFOS use for essential uses where alternatives are not available.[109] This approach would maximise the reduction in PFOS emissions while minimising ongoing costs from PFOS use.[110] It therefore does the most to address the objective of protecting human health and the environment from exposure to PFOS.

Table 11 summarises the measures applying under Option 4.

Table 11. Measures under Option 4

Use	Stockholm category	Controls
Acceptable purpose (ongoing use permitted)		
X-ray photography	Photo-imaging	Imports and manufacture permitted but controlled Users licensed No change to existing industry recycling program
Replacement parts for medical devices	Certain medical devices (i.e. film in old diagnostic devices)	Imports and manufacture permitted but controlled
Specific exemption (use permitted for 5 years)		
Hard chromium plating - open loop	Metal plating (hard metal plating)	Imports and manufacture permitted but controlled for first 5 years, then banned Use is licensed in first 5 years, then banned Requirement to improve processes and capture and destroy PFOS-containing wastes i.e. sludges By year 5 users either - Transition to a non-PFOS alternative - Introduce closed-loop system Environmentally sound waste disposal
Decorative chromium plating	Metal plating (decorative plating)	Imports and manufacture permitted but controlled for first 5 years, then banned

[109] The only known essential uses of PFOS are in X-ray photography and, possibly, in replacement parts for older medical devices.

[110] It is assumed that a low level of accidental emissions would continue to occur during a transition period following the ban, while existing stocks of PFOS are removed from use.

Use	Stockholm category	Controls
and plastics etching		Use is licensed in first 5 years, then banned By year 5 users transition to a non-PFOS alternative Environmentally sound waste disposal
Fire fighting	Fire fighting foam	Banned Environmentally sound waste disposal (i.e. unwanted fire fighting foam concentrate stocks, firewater, contaminated soil)
Any other use for which Australia does not register		
Examples include (but not limited to) treatments for paper, textiles, carpet, clothing, leather, mining, aviation hydraulic fluids		Imports and manufacture banned except for the purpose of environmentally sound disposal Use banned

4.5 Other options excluded based on lack of feasibility

The feasibility of a non-regulatory or co-regulatory approach was considered in accordance with guidance from the OBPR.

Each option includes some non-regulatory approaches, such as information and education campaigns and setting standards. However, non-regulatory, voluntary and co-regulatory options would not be appropriate and adapted to implementing Australia's obligations under the Stockholm Convention in the broad. In particular, legally enforceable obligations which require certain actions and mandate compliance of persons or entities will generally require legislative implementation.

5. WHAT ARE THE IMPACTS OF THE OPTIONS?

5.1 Methodology for impact analysis

This section describes the methodology used in impact analysis.

The impact analysis identifies the likely costs and benefits of each option, relative to the base case of no new government action, in order to guide the selection of a preferred option. The guidelines for RIS impact analysis are set by the OBPR in the Australian Government Department of the Prime Minister and Cabinet.

The analysis identifies the benefits and costs of all the proposed options for business, community organisations and individuals. It shows how the impacts will be distributed across the community and provides an estimate of the regulatory costs to businesses, community organisations and/or individuals using the Regulatory Burden Measurement (RBM) framework. Other costs incurred or avoided by the regulation (such as opportunity costs, indirect costs and the costs to government of regulation) are considered separately from the RBM.

Ideally, the impact analysis would be supported by a cost benefit analysis that identified the monetary value of all benefits, including non-market benefits, allowing for the direct comparison of financial costs and benefits. However, as the OBPR guidance notes, although direct compliance costs are readily estimated, other costs and benefits are often intangible and need to be identified qualitatively rather than calculated.

There is inherent methodological complexity in demonstrating the impacts (or lack thereof) of environmental pollutants like PFOS. To derive the data required for a robust financial analysis of the costs and benefits of regulating PFOS, a comprehensive program of peer-reviewed scientific research would be needed, taking significant resources and time to complete. Further social and economic research would be required to describe the causal links and interactions between environmental, social and economic impacts and to derive standard values for the Australian context that can be compared and summed, across different places and at different scales.

The quantitative data required to carry out such a comprehensive financial analysis of the benefits of regulating PFOS is not yet available. Moreover, it is not expected to become available within a realistic timeframe for government decision-making. In the meantime it is evident that PFOS is imposing not only environmental costs but also flow-on economic and social costs. A comprehensive analysis of the case for government regulation must take into account these currently unquantifiable costs due to market failure, i.e. where the cumulative financial impact of these costs is not adequately reflected in the market and is often subject to significant data gaps and uncertainty.

This impact analysis therefore weighs up qualitative and quantitative information to evaluate the cost-effectiveness and benefits of the options for the regulation of PFOS.

5.1.1 *Cost benefit analysis method*

Where possible, the costs and benefits identified in the impact analysis were quantified in dollar terms. As these dollar figures were generally rounded to two decimal places, there are slight differences in some summations due to rounding.

Table 12 identifies the costs and benefits that could be quantified in these terms.

Table 12. Costs and benefits that could be financially quantified

Category	Item	Option 1	Option 2	Option 3	Option 4
Costs					
Government	Certification associated with imports		✓		
	Regulation development & enforcement			✓	✓
	Product trials & transition costs			✓	✓
	Comprehensive import control process				
	Monitoring of landfill leachate		✓	✓	✓
Industry	Certification associated with imports		✓		
	Replacement cost of alternatives			✓	✓
	Product trials & transition costs			✓	✓
	Site clean-up & waste management		✓	✓	
	Lost farm value of biosolids		✓	✓	✓
	Monitoring of biosolids		✓	✓	✓
	Landfilling of biosolids		✓	✓	✓
	Treatment of biosolids		✓	✓	✓
Benefits/avoided costs					
	No quantifiable benefits				

The summary costings presented in this RIS for the cost benefit analysis and regulatory burden measure are based on the detailed costings and assumptions presented in *Attachment E*. This relies on supporting analysis commissioned by the Department including:

- An initial cost benefit analysis undertaken by Essential Economics (2013). This report uses regulatory options and cost assumptions developed by Infotech (2012a, 2012b, 1012c, 2012d, 2013, 2014).

- An updated cost benefit analysis by Marsden Jacobs Associates (2015). This work broadly used the same cost assumptions as the Essential Economics CBA but updated the costs from 2012-13 to 2014-15 dollar values. The PFOS consumption models were also updated to include revised information on use (Infotech, 2012a, 2012b, 1012c, 2012d, 2013, 2014).

The Department supplemented the costings in preceding CBAs by developing a new base case, updating some assumptions and deferring the start date of the costings model (to 2017-18) to reflect a more realistic implementation date.

The cost–benefit analysis covers a 20 year period (2017-18 to 2036-37) while the RBM is calculated for the first 10 years as per OBPR's guidance. The values are in 2014-15 dollars, updated in many cases from 2012-13 estimates. As no benefits are quantifiable, the CBA results are presented using the present value (PV) of costs incurred, supplemented by qualitative analysis of unquantifiable impacts. A discount rate of 7 per cent was used, consistent with OBPR guidance. Sensitivity analysis using different discount rates (3% and 10%) is provided in the section *Sensitivity analysis of the CBA results*.

Due to the persistent nature of PFOS, PV could have been calculated over a significantly longer time period. However, in the long term the discount rate would have a more significant impact on the results.

The calculations were informed by the material flows analysis modelling the estimated quantities of PFOS used, disposed of and emitted to the environment under each option. For each scenario, trends over time in PFOS use, consumption and emissions were projected by applying the modelled environmental fate of PFOS (see Table 2) to the amount of PFOS consumed for each use in each year of the analysis. These estimates were adjusted as required for each of the options where controls would be put in place to prevent or divert releases to the environment.

Modelled consumption and emissions for each option are included at *Attachment F.* Some assumptions were relevant across options, for example the cost of PFOS destruction on a weight basis. These assumptions and the quantities of PFOS identified by the material flows analysis were combined to estimate the total costs. Further information on assumptions informing the estimated costs is available in *Attachment E.*

The distribution of costs across governments was not calculated as it would depend on the implementation approach. Comments are welcome on possible implementation approaches for each option.

The limited data available meant that a high number of assumptions were used in the CBA and this may limit its predictive power. The Department welcomes any comments or additional information that could help to confirm, refine or improve the assumptions.

The CBA did not attempt to use non-market valuation methods to quantify the benefits associated with avoided impacts on the environment, such as stated and revealed preference, or benefit transfer techniques. These methods are not suitable for costing the regulation of PFOS because of the lack of scientific certainty and the level of knowledge around the impacts of PFOS, particularly its long-term impacts. Without reliable scientific evidence, none of those valuation methods can provide consistent, reliable estimates for health, environmental and social benefits of PFOS emissions reduction.

The CBA therefore significantly underestimated the total benefits that could be realised by Australia taking action to reduce PFOS emissions. These gaps in the quantitative analysis are addressed by the qualitative analysis.

5.1.2 Qualitative analysis method

The qualitative analysis for this RIS drew on a wide range of publicly available data to address key gaps in the CBA. It identified themes, issues, trends and insights, including the human motivations, beliefs, behaviours and values to be taken into account in the overall assessment of costs and benefits of the proposed regulation options.

The qualitative analysis approach was predicated on the assumption that the national impact of regulating PFOS is the cumulative outcome of changes at the local level. Although the science is not yet advanced enough to quantitatively model these local impacts and benefits, local trends were identified that would be likely to lead to cumulative impacts at the national level. In this way, overall trends in key areas of interest at the national level could be projected.

The foundation of this analysis was the environmental impacts of PFOS identified in Table 3 and Table 4, and the potential flow-on impacts on human communities including economic and social costs. As a starting point, the changes that lower PFOS emissions are expected to have on environmental impacts were mapped to identify the economic and social impacts of the options.

Limitations of this approach include the inherent complexity and unpredictability of environmental change and the limited data available on how PFOS affects Australian species, ecosystems and natural resources. As a result, changes due to reducing PFOS emissions may be difficult or impossible to distinguish in practice from the impacts of other environmental changes taking place at the same time.

The analysis also took into account intangible values, such as the intangible value of community perceptions regarding a safe and clean environment, as a factor in economic and social impacts. These perceptions can significantly influence quality of life and behaviour for individuals, communities, businesses and government and hence lead to economic and social costs and benefits. The analysis drew extensively on reports from Australian communities affected by past PFOS contamination, particularly at Williamtown in NSW and Oakey in Queensland, to understand community perceptions.

This approach allowed the transparent and replicable identification of unquantifiable impacts.

5.2 Summary of impacts

The following discussion of impacts looks separately at impacts for individuals and the community, business and government. This reflects the RIS impact analysis requirements set by the Office of Best Practice Regulation.

The following tables present the economic impacts (Table 13) and social impacts (Table 14) of PFOS regulation. These should be read alongside Table 3 and Table 4 outlining the environmental impacts of PFOS under the base case. Although each option for action would deliver a different level of PFOS regulation and therefore a different reduction in PFOS emissions, these tables remain valid for each option.

Table 13. Unquantified economic impacts of phasing out PFOS[111]

Type	At PFOS sites[112]	Linked to PFOS sites	Economy-wide
Communities, households and individuals	↓ additional support services & health & safety measures not funded by employer ↓ lobbying & advocacy in relation to workplace PFOS issues	↓ testing, upgrading or replacing household water supply ↓ substituting for domestically produced food ↓ seeking professional advice ↓ opportunity costs of selling or financing property ↓ need to substitute for seafood & other wild foods ↓ services & support to address community concerns ↓ lobbying & advocacy in relation to local PFOS issues ↓ opportunity costs of PFOS-related expenditure	↓ altered recreation and tourism behaviours in response to concern about PFOS ↓ altered food purchase behaviours in response to concern about PFOS ↓ altered health behaviours in response to concern about PFOS ↓ lobbying, advocacy & litigation in relation to producer responsibility ↓ lobbying & advocacy in relation to broader PFOS environmental impacts & human health concerns
Businesses (including PFOS users)	↓ litigation and compensation ↓ uncertainty	↑ demand for PFOS waste transport, disposal & destruction services ↓ fisheries closures or restrictions ↓ contamination, environmental impact & human health monitoring ↓ advertising and publicity to maintain or restore brand value & goodwill ↑ demand for products from businesses directly reliant on the environment & broader multiplier benefits ↓ opportunity costs of PFOS-related expenditure ↑ economic productivity of environmental assets	↓ increased pressure on waste management & landfill services ↓ contamination of biosolids ↓ opportunity cost of expenditure on PFOS ↓ monitoring for businesses directly reliant on the environment[113]
Governments	↓ litigation & compensation ↓ monitoring of onsite contamination ↓ monitoring of contamination downstream from site ↓ onsite management when polluters cannot pay	↓ monitoring of contamination, environmental impacts & human health concerns ↓ responding to lobbying & advocacy ↓ offsite management, remediation, welfare & compensation when polluter cannot pay	↓ increased demand on health services, including mental health services and blood testing services ↓ contamination of biosolids ↓ increased complexity & risk of urban & regional planning processes ↓ opportunity cost of PFOS-related expenditure

Notes:

↑ = increased effect / impact

↓ = decreased effect / impact

[111] The benefits increase progressively from Option 2 to Option 4, reflecting the progressive reduction in PFOS emissions.

[112] PFOS sites are sites where PFOS would have been used in the absence of a phase out.

[113] Businesses directly reliant on the environment include: farming, fishing, horticulture, livestock, food, beverage and wine production, tourism and recreation.

Table 14. Unquantified social impacts of phasing out PFOS[114]

Type	At PFOS sites[115]	Linked to PFOS sites	Society-wide
Communities, households and individuals	↓ anxiety, stress and uncertainty for site managers and workers due to PFOS concerns	↓ anxiety, stress and uncertainty for residents due to PFOS concerns ↓ changed health behaviours due to PFOS concerns ↓ lifestyle disruption, such as travelling to access PFOS-related services ↓ externally imposed major disruption related to PFOS contamination, such as having to move house ↑ maintenance of family and community connections ↓ loss of amenity from changed consumption and recreation behaviours ↓ conflict with PFOS-using industry and government ↑ certainty regarding community priorities and sustainability ↑ public confidence and trust in the ability of business and all levels of government to manage environmental risks and health concerns	↓ inequity due to uneven distribution of impacts ↓ loss of amenity from changed food consumption behaviours, e.g. seafood ↓ anxiety, stress and uncertainty due to PFOS concerns) ↓ loss of amenity from changed tourism and recreation behaviours ↓ loss of amenity from changed health behaviours ↑ preservation of non-use value of environment ↓ conflict with business and government due to PFOS concerns ↓ uncertainty about community sustainability due to PFOS concerns ↑ public confidence and trust in the ability of business and government to manage environmental risks and health concerns
Businesses (including PFOS users)	↓ uncertainty about business continuity, social licence to operate and liability due to PFOS concerns ↓ conflict with other businesses, the community and government due to PFOS concerns ↑ risk management outcomes due to transition from PFOS	↓ anxiety, stress and uncertainty due to business impacts of PFOS concerns, particularly for small businesses ↑ public confidence and trust in the ability of business to manage environmental risks and health concerns	↓ anxiety, stress and uncertainty due to business impacts of PFOS concerns, particularly for small business ↑ public confidence and trust in the ability of business to manage environmental risks and health concerns
Governments	↓ change or uncertainty due to PFOS concerns	↑ public confidence and trust in the ability of government to manage environmental risks and health concerns	↑ public confidence and trust in the ability of all levels of government to manage environmental risks and health concerns

Notes:

↑ = increased effect / impact

↓ = decreased effect / impact

[114] The benefits increase progressively from Option 2 to Option 4, reflecting the progressive reduction in PFOS emissions.

[115] PFOS sites are sites where PFOS would have been used in the absence of a phase out.

5.2.1 Community impacts

The following discussion of community impacts includes households and individuals.

The analysis has not identified any costs of the proposed regulation to the community, households and individuals. Consumer costs are not expected to rise significantly due to the regulation of PFOS. The marketplace is highly competitive, with alternatives available for most uses, and the costs of transitioning away from PFOS would form part of ongoing capital expenditure and production costs for business.

The analysis has identified a range of economic and social benefits to the community, households and individuals arising from the regulation of PFOS, as shown in Table 13 and Table 14. For the most part, these benefits reflect the flow-on impacts of environmental improvements due to reduced PFOS emissions and the reduced total burden of PFOS contamination in the environment.

Importantly, avoiding future PFOS contamination would protect communities, households and individuals from the potential costs, risks and uncertainties of dealing with contamination. For example, some people who would be exposed to PFOS, or would fear being exposed to PFOS, in the absence of regulation are likely to experience improved psychosocial health due to a decline in stress linked to anxiety about PFOS exposure. This marginal reduction in individual stress could deliver population-level improvements in psychological and physical health, such as reduced anxiety or hypertension, noting these improvements might not be measurable.

At the individual level, the extent and value of any benefits experienced will vary depending on factors such as each person's beliefs about PFOS exposure, their personal situation and socioeconomic context. However, at the community and population level the overall impacts could be considerable.

5.2.2 Business impacts

The following discussion of business impacts includes businesses that currently use PFOS, other businesses in the same industries, and businesses in the broader economy.

The analysis has also identified a range of social and economic benefits to business arising from the regulation of PFOS, as shown in Table 13 and Table 14. For the most part, these benefits reflect the flow-on impacts of environmental improvements due to reduced PFOS emissions and the reduced total burden of PFOS contamination in the environment.

The benefits to businesses that are directly reliant on the environment are an important consideration. For example, for the seafood industry, the economic impacts arising from PFOS contamination of local surface waters such as lost income and brand damage could equal or exceed any direct environmental damage. One driver of these impacts is the uncertainty and concern among government, businesses and consumers on food quality and safety. Similar considerations apply to agriculture and livestock farming.

The phase out of PFOS use will also benefit businesses that currently use PFOS, by reducing, or in most cases ending, any potential future liability due to environmental contamination arising from their PFOS emissions. Future costs could include compensation, 'make good' payments, or legally enforceable cleanup of contaminated sites. Box 12 provides more information on potential legal liability associated with chemical pollution. Although these reduced liabilities are currently unquantifiable, they are potentially higher than the direct costs identified in the CBA.

Box 12. Legal liability associated with chemical pollution

Individuals and communities may take legal action against governments or businesses to seek compensation for impacts from direct or indirect exposure to harmful chemicals.

For example, in February 2017 the United States chemical companies DuPont and Chemours agreed to a $670.7 million settlement for over 3,500 lawsuits relating to six health conditions linked by the plaintiffs to perfluorooctanoic acid (PFOA, used to make Teflon) from DuPont's Washington Works Plant in West Virginia into the Ohio River where it entered the drinking water supply.[116] DuPont had previously settled a related class action lawsuit for $70 million in 2005.The 2017 settlement followed several successful individual lawsuits. The first case went to trial in 2015 and the plaintiff with kidney cancer was awarded $1.6 million.[117] In July 2016, a plaintiff with testicular cancer was awarded $5.1 million compensatory damages with an additional $500,000 in punitive damages.[118]

In Australia, the Department of Defence is the respondent in a class action seeking compensation for damage to property owners and businesses caused by contamination at the Williamtown Royal Australian Air Force base.[119, 120] Commercial and recreational fishing closures were in effect from September 2015 to October 2016, with the commercial dusky flathead fishery not reopened until April 2017.[121] One prawn trawler estimated losses of up to $100,000 in March 2016.[122] Residents report that their properties have been devalued.[123] In Oakey, around 450 people have joined a class action seeking compensation for economic loss from residential, agricultural and business land as a result of the contamination at the nearby Army Aviation Centre.[124, 125]

Businesses that provide PFOS waste transport, disposal or destruction services will also experience benefits through increased demand. The highest demand will be under Options 2 and 3 as these include continued use of PFOS-containing fire fighting foam for fire fighting, with associated costs for environmentally appropriate firewater cleanup and disposal, including destruction where necessary. The high cost estimated in this RIS for site cleanup and waste management where fire fighting foams are used (estimated at an average

116 http://investors.dupont.com/investor-relations/investor-news/investor-news-details/2017/DuPont-Reaches-Global-Settlement-of-Multi-District-PFOA-Litigation/default.aspx

117 http://www.reuters.com/article/us-du-pont-c8-verdict-idUSKCN0S12KE20151007

118 http://www.reuters.com/article/us-dupont-verdict-idUSKCN0ZO21V

119 http://www.theherald.com.au/story/3810658/williamtown-residents-launch-class-action-against-defence/?cs=305

120 https://www.imf.com.au/cases/register/williamtown-overview

121 http://www.dpi.nsw.gov.au/about-us/media-centre/releases/2016/fishing-closures-at-williamtown-to-be-lifted

122 http://www.abc.net.au/news/2016-03-23/residents-launch-class-action-over-williamtown-contamination/7269538

123 http://www.theherald.com.au/story/3800346/hunter-river-prawners-count-costs/?cs=305

124 https://www.shine.com.au/service/class-actions/oakey-landholder-claims and https://www.comcourts.gov.au/file/Federal/P/NSD1155/2017/actions

125 http://www.abc.net.au/news/2017-03-17/oakey-class-action-set-to-commence/8365386 and *Hudson and Ors v Commonwealth (*Federal Court proceedings NSD1155/2017*).*

$830,853 per site) represents a lower bound estimate. Costs are likely to be much higher to remediate a site where PFOS has contaminated the surrounding area after entering groundwater and moving off-site.

There are significant uncertainties associated with the expected benefits of each option for business. It is unknown how many facilities are already taking steps, or may take steps in the future, to reduce or eliminate PFOS use in response to evolving state and territory regulation. It is possible that under Options 2 and 3 an unknown number of facilities currently using PFOS-containing fire fighting foam would reconsider and reduce or eliminate its use due to the higher built-in cost of appropriate cleanup and waste disposal, including destruction where necessary (estimated at an average $830,853 per site) that would be required.

Waste disposal and wastewater treatment issues are discussed in section 5.2.3 *Government impacts*.

5.2.3 Government impacts

The following discussion of government impacts includes waste disposal and wastewater treatment authorities as these functions usually sit with state, territory and local governments or independent authorities owned by government.

Australia would benefit from efficiencies from a nationally consistent and effective implementation scheme for chemicals listed under the Stockholm Convention. The Stockholm Convention goes through a continuous process of listing chemicals. In recent years, other chemicals have also been listed with implementation requirements (such as controls on import, export, manufacture and use, and management of waste and biosolids) similar to PFOS. Appropriate regulatory controls for industrial chemicals established through the ratification of the listing of PFOS would deliver efficiencies for future treaty actions by leveraging these existing legislation, programs and compliance arrangements.

For example, in the wastewater sector, for chemicals listed under the Stockholm Convention that are still used in Australia (or are present in leachate at levels that require monitoring), efficiencies may be realised for regulation development, enforcement and sampling for leachate monitoring. It is expected that savings of 50 per cent of estimated costs for these activities would be realised if action were taken concurrently for more than one chemical.

Under a certification approach, the certification of PFOS is not expected to lead to efficiencies with other chemicals except where leachate sampling is required.

5.3 Analysis of options

The options and the measures under each option are summarised in Table 7 and Table 8. The four options differ in their cost and likely effectiveness in achieving the outcomes sought from regulation of PFOS to:

- Address the challenges for Australia arising from the listing of PFOS for restricted use under the Stockholm Convention

- Support and strengthen state and territory actions to reduce future exposure of humans and the environment to PFOS as a precaution
- Minimise externality costs from future PFOS use, particularly to Australian communities and businesses.

5.3.1 Option 1: No new policy intervention

Option 1 represents the scenario where the Government would not take any additional action to reduce PFOS emissions or phase out its use. This option establishes the baseline for Options 2, 3 and 4.

Option 1 does not achieve any improvement on the current trend of a gradual reduction in Australia's PFOS emissions. The decline in PFOS use in Australia over the past decade reflects industry responses to non-regulatory recommendations to phase out its use and changes in the international market. The main feature of the base case is that it assumes that PFOS use and thus emissions will continue to decline in Australia over the modelled period, albeit at a slower rate than that seen over the last decade. The single largest source of emissions is releases from the use of existing stocks of PFOS-containing fire fighting foam.

However, potential future changes in the Australian marketplace due to global developments in chemicals management introduce high uncertainty around the estimates. In particular, under this scenario there would be nothing to prevent the import of PFOS-containing fire fighting foam from countries where use has been phased out. New imports that add to the existing Australian stocks for this use could significantly increase the emissions baseline.

Option 1 also represents an uncertain future for Australia due to continued industry reliance on imports of PFOS for multiple ongoing uses. Most countries, including Australia's main sources of PFOS, have ratified the listing of PFOS in the Stockholm Convention. Future PFOS imports could be at risk if Australia does not certify or ratify the listing of PFOS under the Stockholm Convention.

5.3.1.1 Impact analysis

Consultation with industry suggests that the transition to non-PFOS alternatives is already underway or complete for many businesses. As the costs to business of transition in the base case are not considered, the marginal costs of transition in the other options may be overestimated.

Australian businesses and governments could experience a range of potential impacts under this option that are unquantifiable but significant.

Existing users of PFOS in chromium plating, X-ray and medical devices could experience significant short-term costs under the base case, due to the blockage or interruption of PFOS imports without warning or without a sufficient transition period. This situation may arise if a country supplying PFOS to Australia is a Party to the Stockholm Convention as Australia would be unable to provide certification for imports under the base case. These potential costs to business are currently unquantifiable and are considered in the qualitative analysis, informing the identification of the preferred option.

The effect of an interruption in supply on PFOS emissions is not estimated here, due to uncertainty of timing and extent. However, an interruption in imports may not significantly affect the baseline emissions as most emissions are thought to arise from consumption of existing stockpiles.[126]

No costs for site cleanup after use of fire fighting foams are estimated for the base case as there is too much uncertainty regarding the timing and frequency of site cleanup. This uncertainty reflects the differing and rapidly evolving approaches to regulating fire fighting foam use and waste disposal, including waste destruction requirements, across jurisdictions. It is also not possible to quantify the potential costs of new contaminated sites, such as legal liabilities or environmental impacts.

Other impacts, such as environmental and human health impacts, would be greatest for the base case. As such, the other options which reduce pollution compared with the base case are expected to realise greater benefits from these avoided costs than it is possible to quantify here.

5.3.1.2 Cost benefit analysis

Cost benefit analysis was not conducted for Option 1 as it is the baseline for the other options.

The level of PFOS emissions provides an indication of the unquantifiable costs of business as usual in the baseline option. The continuation of business as usual in Option 1 is estimated to result in 25.74 tonnes of PFOS emissions to the Australian environment over the 20 years from 2017-18 to 2036-37. The quantity of PFOS emissions under this scenario would be over 40 times higher than the lowest emissions scenario presented in Option 4. This estimate is subject to refinement through the RIS consultation process.

5.3.2 Option 2: Do not ratify, but implement certification requirements

5.3.2.1 Impact analysis

The main outcome of Option 2 would be to provide certainty to industry on future PFOS imports and requirements for its management. This option also achieves a significant reduction in emissions of PFOS through more appropriate controls on releases and improved waste management. It is consistent with the broad direction of state and territory regulation.

Although there would be costs to businesses that use PFOS, this option is not expected to significantly accelerate the phasing out of PFOS use. The transition to PFOS alternatives (for uses other than fire fighting) is not costed for this option as, to the extent that it occurs, this is assumed to be due to external factors.

There are four key activities under Option 2.

The Government would provide annual certification to exporting Parties to secure future PFOS imports. This would be an administrative process coordinated by the Government.

[126] Emissions from existing stocks of fire fighting foams are modelled to account for 94.0 per cent of releases over the first 10 years, decreasing to 90.9 per cent of releases over the full 20 year period.

Supporting elements may include legislation, regulatory instruments, administrative or policy guidelines from all levels of government. The Government would incur the majority of certification costs although businesses are likely to incur a small cost from the work required to provide supporting information. Industry education campaigns to raise awareness of the changes would complement certification processes.

Management of PFOS releases from waste infrastructure would be improved through the implementation of management standards or other controls, such as the monitoring and appropriate disposal, including destruction where appropriate, of landfill leachate and biosolids containing elevated PFOS. This would involve collaborative action between the Government, state and territory governments and sewage treatment plant operators.

Governments would introduce standards, waste classifications or other controls as needed to ensure the collection and environmentally sound disposal of unwanted stocks of PFOS-containing products along with firewater and metal plating wastes that contain PFOS.

5.3.2.2 Cost benefit analysis

The anticipated benefits of Option 2 include:

- Estimated reduction in PFOS emissions compared to Option 1 is 23.57 tonnes (from 25.74 tonnes to 2.17 tonnes) over the next 20 years at an average cost of $4276 per kilogram or $4.28 million per tonne of PFOS emissions prevented
- Improved certainty for business on future PFOS import supply.
- Certainty and consistency for business on PFOS management requirements across Australia.
- Prevention or reduction of environmental impacts and potential liability from continuing fire fighting use by ensuring cleanup.
- Realisation of some efficiencies where action is taken on other Stockholm Convention listed chemicals (i.e. sampling of waste infrastructure).

No costs to individuals or community groups were identified.

The total costs to government over the 20 year period of the CBA are $2.62 million, comprising:

- Certification: Import certification would cost $2.23 million. This includes one-off establishment costs and ongoing annual costs.
- Waste infrastructure emissions: Monitoring of landfill leachate would cost $0.40 million. This includes annual costs for year 1 to year 5 only.

The total costs to industry over the 20 year period of the CBA are $98.17 million, comprising:

- Certification: Reporting and record keeping would cost $1.42 million to support annual PFOS import certification by the Government. This cost would be ongoing and apply to all businesses using PFOS.

- Cost of alternatives: Appropriate disposal and replacement of PFOS-containing products would cost $7.82 million. For Option 2 this cost would apply only to businesses disposing of and replacing PFOS-containing fire fighting foam.

- Waste management: Improved waste management would cost $81.19 million as follows. For the hard chromium plating industry, process improvement and waste management would cost $2.29 million, comprising $0.04 million for process improvement and $2.25 million for waste management. These costs would be ongoing. For fire fighting where PFOS-containing fire fighting foam continues to be used, site cleanup and waste disposal would cost $78.89 million. This cost would be ongoing.

- Waste infrastructure emissions: For water utilities, monitoring and management of biosolids would cost $7.74 million, comprising $0.57 million for monitoring and $7.17 million for waste management of PFOS-containing biosolids. These costs would be ongoing for five years for monitoring, while the subsequent management costs would apply only if the monitoring found elevated PFOS in biosolids. If so, the management cost would include the cost of appropriate disposal or treatment of PFOS-containing biosolids and the lost farm value for biosolids diverted from use.

The costs for each industry are presented in Table 15 in terms of Present Value (PV).

Table 15. Industry costs for Option 2 compared to the base case

Industry	PV ($m)
Hard chromium plating	2.47
Decorative chromium plating	1.04
Plastics etching	0.01
X-ray photography	0.02
Fire fighting	86.90
Water utilities	7.74
Total industry costs	**98.17**

The CBA results for Option 2 are presented in Table 16 in terms of PV. See the section *Cost benefit analysis method* for information about how the CBA was calculated.

As discussed above, no benefits were quantified, reflecting the fact that the benefits expected from a reduction in PFOS emissions are unquantifiable. See the section *Qualitative analysis method* for more information.

Table 16. CBA summary for Option 2 compared to the base case

Type of cost or benefit		PV ($m)
Benefits		
No quantified benefits		0.00
Total Benefits		0.00
Costs		
Certification	Industry	1.42
	Government	2.23
Cost of alternatives	Industry	7.82
Waste management	Industry	81.19

Type of cost or benefit		PV ($m)
Releases from waste infrastructure	Industry	7.74
	Government	0.40
Total Costs		100.80

The certification costs to industry are high. The main driver for this result is the high cost for certification of PFOS-containing fire fighting foam used in fire fighting due to the requirement for improved waste management practices, particularly the collection of firewater following use and appropriate disposal (including destruction where necessary) of its PFOS content. This action contributes both the largest cost and the largest contribution to reducing emissions under this scenario.

Additional benefits (such as improved certainty for importing businesses, other avoided impacts to health and the environment, and avoided legal liabilities) are expected for Option 2 but could not be quantified. The unquantified benefits that directly relate to emissions will be less for Option 2 compared to Options 3 and 4 as those scenarios reduce emissions to a greater extent.

Other unquantified benefits are also expected to be comparatively less for Option 2 than Options 3 and 4. This is because certification imparts less potential than ratification for Australia to influence international decision-making on PFOS and realise efficiencies in future action taken on other Stockholm Convention chemicals. The relative value of these benefits is further elaborated in Options 3 and 4.

5.3.3 Option 3: Ratify and register permitted uses

5.3.3.1 Impact analysis

Ratification would involve registering for the PFOS uses that are identified as relevant to Australia and banning import, export, manufacture and use of PFOS for any other uses.

For the PFOS uses identified as relevant to Australia, the one difference between Options 2 and 3 is that, instead of administrative processes for import certification, legislative processes would be put in place under Option 3 that are appropriate and adapted to implementing Australia's obligations under the Stockholm Convention. This would likely involve licensing PFOS importers, exporters, manufacturers and users. Licenses could only be issued for a currently registered use or where the activity would be consistent with the requirements of the Stockholm Convention.

Ratification would require phasing out PFOS use in the decorative chromium plating and plastics etching industries. Businesses that still use PFOS would incur costs to transition to non-PFOS alternatives. The hard chromium industry is also expected to increase its uptake of non-PFOS alternatives compared to Options 1 and 2 as businesses would choose to upgrade to closed-loop systems using PFOS, or stop using PFOS. Governments would provide information and education campaigns for these industries and may support non-PFOS product trials.

The impacts from measures to improve management of PFOS in ongoing uses and wastes are expected to be similar to Option 2. However, there may be a stronger focus on regulation rather than self-regulation or voluntary action.

5.3.3.2 Cost benefit analysis

The anticipated benefits of Option 3 include:

- Estimated reduction in PFOS emissions compared to Option 1 is 24.21 tonnes (from 25.74 tonnes to 1.54 tonnes) over the next 20 years at a cost of $4153 per kilogram or $4.15 million per tonne of PFOS emissions prevented.
- Certainty for business on future PFOS import supply – more than Option 2 and similar to Option 4. These additional benefits are a result of ratification enabling Australia to better represent its interests through registration and reporting in relation to PFOS to inform decision-making on future changes to the listing of PFOS under the Stockholm Convention.
- Certainty and consistency for business on PFOS management requirements across Australia - similar to Options 2 and 4.
- Prevention or reduction of environmental impacts and potential liability associated with continuing fire fighting use - similar to Option 2.
- Realisation of efficiencies where action is taken on other Stockholm Convention listed chemicals (i.e. regulation development and enforcement costs) – more than Option 2 and similar to Option 4.

No costs to individuals or community groups were identified.

The total costs to government over the 20-year period of the CBA comprise:

- Regulation: Licensing, development and enforcement of regulation and other implementation costs, such as reporting to the Stockholm Convention and non-regulatory activities to support the transition away from PFOS, would cost $2.09 million. This is lower than the comparable cost for certification in Option 2.
- Releases from waste infrastructure: Monitoring of landfill leachate would cost $0.40 million. This includes annual costs for year 1 to year 5 only. This is the same as for Option 2.

The total costs to industry over the 20-year period of the CBA comprise:

- Licensing: Reporting and record keeping would cost $0.26 million to support licensing of PFOS use by the Government. This cost would be ongoing for all users of PFOS (other than fire fighting).
- Cost of alternatives: Appropriate disposal and replacement of PFOS containing products would cost $9.80 million. For Option 3 this cost would apply to all industries that use PFOS, other than X-ray photography. It would cover product trials, system changes, and the cost of alternative products and destruction of old stock. The transition rates, timing

and costs would vary by industry. The cost is more than Option 2, where transition costs are only included for fire fighting.

- Waste management: Improved waste management would cost $80.24 million as follows. For the hard chromium plating industry, process improvement and waste management would cost $1.36 million, comprising $0.03 million for process improvement and $1.33 million for waste management. These costs would be ongoing and are less than Option 2, as Option 3 assumes increased transition to alternatives. For the continued use of PFOS-containing fire fighting foam in fire fighting, site cleanup and waste disposal, including destruction where necessary, would cost $78.89 million. This cost would be ongoing and is the same as for Option 2.

- Waste infrastructure emissions: For water utilities, monitoring and management of biosolids would cost $7.74 million, comprising $0.57 million for monitoring and $7.17 million for waste management of PFOS containing biosolids. These costs would be ongoing for five years for monitoring, while the subsequent management costs would apply only if the monitoring found elevated PFOS in biosolids. If so, the management cost would include the cost of appropriate disposal or treatment of PFOS-containing biosolids and the lost farm value for biosolids diverted from use. These costs are the same as for Option 2.

The costs to each industry are summarised in Table 17 in terms of Present Value (PV).

Table 17. Industry costs for Option 3 compared to the base case

Industry	PV ($m)
Hard chromium plating	2.60
Decorative chromium plating	0.58
Plastics etching	0.40
X-ray photography	0.02
Fire fighting	86.72
Water utilities	7.74
Total industry costs	**98.05**

The CBA results for Option 2 are presented in Table 18 in terms of PV. See the section *Cost benefit analysis method* and the Marsden Jacob Associates CBA extracts at *Attachment C* for information about how the CBA was calculated.

Once again, no benefits were quantified. See the section *Qualitative analysis method* for more information.

Table 18. CBA summary for Option 3 compared to the base case

Type of cost or benefit			PV ($m)
Benefits			
	No quantified benefits		0.00
Total Benefits			0.00
Costs			
	Regulation and licensing	Industry	0.26
		Government	2.09
	Cost of alternatives	Industry	9.80
	Waste management	Industry	80.24

Type of cost or benefit		PV ($m)
Releases from waste infrastructure	Industry	7.74
	Government	0.40
Total Costs		100.53

Compared to Option 2, Option 3 achieves greater benefits due to lower emissions of PFOS, noting this benefit is unquantified. The main driver for the CBA result is again the large costs that would be incurred by businesses holding stocks of, or continuing to use, PFOS-containing fire fighting foam.

Additional unquantified benefits are expected, many of which will be similar to Option 2 but at a higher level, proportional to the further reduction in emissions under Option 3. The ratification of the listing of PFOS in the Stockholm Convention is also expected to realise additional benefits. As well as securing imports for ongoing uses of PFOS, it would strengthen Australia's ability to influence international decision-making on PFOS. It would also realise further efficiencies should future action be taken on other Stockholm Convention chemicals.

5.3.4 Option 4: Ratify and phase out all non-essential uses

5.3.4.1 Impact analysis

This option would require businesses in the fire fighting, hard chromium plating, decorative chromium plating and plastic etching industries to phase out PFOS use. These industries would incur costs from transitioning to alternatives and disposing of unwanted stocks in accordance with the requirements of the Stockholm Convention. Strategies to identify stockpiles and ensure appropriate waste disposal will be important if Australia is to prevent illegal dumping of remaining PFOS stocks or contaminated material.

This option also introduces a labelling scheme to increase collection rates for X-rays. A recycling program is already in place targeting silver recovery. The process used is also effective in destroying the PFOS content, so increasing X-ray collection rates would contribute to controlling PFOS emissions.

The main sources of PFOS contamination in waste infrastructure, particularly sewage treatment plants, are not yet known. As such, even though most PFOS uses would be banned, monitoring of waste infrastructure would still be required along with appropriate management of PFOS-containing wastes until the monitoring shows that PFOS is no longer present at a concerning level.

5.3.4.2 Cost benefit analysis

The anticipated benefits of Option 4 include:

- Estimated reduction in PFOS emissions compared to Option 1 is 24.2 tonnes (from 25.12 tonnes to 0.62 tonnes) over the next 20 years at a cost of $1542 per kilogram or $1.54 million per tonne of PFOS emissions prevented.

- Certainty that Australia does not become one of the few countries where the supply of PFOS-related chemicals, articles, and manufactured products such as fire fighting foam remains legal.

- Certainty for business on future PFOS import supply – more than Option 2 and similar to Option 3.

- Certainty and consistency for business on PFOS management requirements across Australia – similar to Options 2 and 3

- Prevention of potential liability and environmental impacts associated with site contamination from continuing fire fighting use – more than Options 2 and 3. While Options 2 and 3 both assume 100 per cent compliance for the required cleanup of sites where PFOS is used, emissions are likely to still occur due to delayed cleanup or incomplete recovery of PFOS in firewater. The model therefore assumes a 95 per cent reduction of emissions to surface waters for the controls introduced under Options 2 and 3. The additional benefits for Option 4 arise from the ban on PFOS-containing fire fighting foams, which would stop any new contamination from this use. Not only does this avoid cleanup costs, it prevents the impacts of delayed or incomplete cleanup.

- Realisation of efficiencies in regulation development and enforcement where action is taken on other Stockholm Convention listed chemicals - similar to Option 3

The total costs to governments over the 20-year period of the CBA are $3.84 million, comprising:

- Regulation: Licensing, development and enforcement of regulation and other implementation costs, such as reporting to the Stockholm Convention and non-regulatory activities to support the transition away from PFOS, would cost $3.38 million. This cost is higher than Options 2 and 3.

- Releases from waste infrastructure: Monitoring of landfill leachate would cost $0.45 million. This includes annual costs for year 1 to year 5 only. This is more than Option 2 and 3.

The total costs to industry over the 20-year period of the CBA are $34.91 million, comprising:

- Licensing: Reporting and record keeping would cost $0.18 million to support licensing of PFOS use by the Government. This cost would be ongoing for all users of PFOS (other than fire fighting). This cost is only slightly lower than for Option 3, reflecting the assumption that it takes five years for the chromium plating industries to complete the transition to non-PFOS alternatives. A more realistic timeframe for accelerated phase out will be tested during the consultation.

- Cost of alternatives: Appropriate disposal and replacement of PFOS containing products would cost $22.86 million. For Option 4 this cost would apply to all industries that use PFOS, other than X-ray photography. It would cover product trials, system changes, and the cost of alternative products and destruction of old stock. The transition rates, timing and costs would vary by industry. These costs are significantly higher than Options 2 and 3, due mainly to the increased destruction and replacement costs for all existing fire fighting foam stocks.

- Waste management: Waste management would cost $4.14 million. For the hard chromium plating industry, there are no waste management costs as it is assumed that all businesses transition to PFOS alternatives. For the X-ray photography industry, the labelling and recycling program would cost $0.63 million. This is an ongoing new cost for this option. For the transition away from PFOS-containing fire fighting foam in fire fighting, site cleanup and waste disposal, including destruction, would cost $3.50 million. This cost would apply during the two-year transition period only. These waste management costs are much lower than Options 2 and 3 due to the end of PFOS use in all industries except for X-ray photography.
- Waste infrastructure emissions: For water utilities, monitoring and management of biosolids would cost $7.74 million, comprising $0.57 million for monitoring and $7.17 million for waste management of PFOS-containing biosolids. These costs would be ongoing for five years for monitoring, while the subsequent management costs would apply only if the monitoring found elevated PFOS in biosolids. If so, the management cost would include the cost of appropriate disposal or treatment of PFOS-containing biosolids and the lost farm value for biosolids diverted from use. These costs are the same as for Options 2 and 3.

The costs to each industry are summarised in Table 19 in terms of Present Value (PV).

Table 19. Industry costs for Option 4 compared to the base case

Industry	PV ($)
Hard chromium plating	2.20
Decorative chromium plating	0.58
Plastics etching	0.40
X-ray photography	0.64
Fire fighting	23.36
Water utilities	7.74
Total industry costs	**34.91**

The CBA results for Option 2 are presented in Table 20 in terms of PV. See the section *Cost benefit analysis method* and the Marsden Jacob Associates CBA extracts at *Attachment C* for information about how the CBA was calculated.

No quantified benefits were found, reflecting the fact that the benefits expected from a reduction in PFOS emissions are unquantifiable. See the section *Qualitative analysis method* for more information.

Table 20. CBA summary for Option 4 compared to the base case

Type of cost or benefit			PV ($m)
Benefits			
	No quantified benefits		0.00
Total Benefits			0.00
Costs			
	Regulation and licensing	Industry	0.18
		Government	3.38
	Cost of alternatives	Industry	22.86
	Waste management	Industry	4.14
	Releases from waste infrastructure	Industry	7.74
		Government	0.45
Total Costs			38.75

The costs for Option 4 are comparatively low. The main driver for the result is that this option avoids high costs for waste management of PFOS-containing fire fighting foam used in fire fighting after the first two years. Although the cost of alternatives is higher than for other options due to all industries except X-ray photography transitioning away from PFOS use, this is significantly outweighed by the avoidance of waste management costs that would be incurred with continued PFOS use.

Option 4 achieves the greatest reduction in emissions of PFOS and other benefits that cannot be quantified financially. The CBA underestimates these benefits, notably the avoided costs of contaminated sites realised by banning PFOS-containing fire fighting foam under this option. An estimate is not available for other avoided costs associated with contamination such as litigation costs or the environmental impacts of environmental pollution. An indication of these costs is provided in sections 2.2.3 *What are the environmental impacts of PFOS?* and 5.2 *Summary of impacts*.

5.3.5 Regulatory burden measurement

The proposed costs from Government regulation, whether arising from new regulations or changes to existing regulation, are quantified using the Regulatory Burden Measurement (RBM) framework.[127] The RBM provides an estimate of the cost of regulation for individuals, community organisations and business, including Government Owned Corporations.

The calculation excludes business as usual costs, including costs incurred under the base case of no new government action. This approach is designed to allow stakeholders to provide feedback focusing on the impacts of the proposed regulation, particularly any unforeseen or unintended consequences.

The RBM values are a simple average of costs to industry over the first 10 year period (2015-16 to 2024-25) using 2014-15 real values. These costs are disaggregated by type as shown in Table 21, consistent with the RBM guidance.

[127] See https://www.dpmc.gov.au/regulation/regulatory-burden-measurement.

Table 21. Regulatory Burden Measurement (RBM) framework

Cost Type		Cost Description
Compliance	Administrative	Costs incurred primarily to demonstrate compliance with the regulation, such as the costs of: • making, keeping and providing records • notifying the government of activities • conducting tests
	Substantive	Costs incurred to deliver the outcomes sought by the regulation, such as the costs of: • providing training to meet regulatory requirements • purchasing and maintaining plant and equipment • providing information to third parties • operating, e.g. energy costs • professional services, e.g. legal advice
Delay	Application	Costs due to the time taken to prepare an application
	Approval	Costs due to the time taken to approve an application

The industries using PFOS that are projected to incur RBM costs include:

- Hard chromium plating
- Decorative chromium plating
- Plastics etching
- X-ray photography
- Fire fighting at major hazard facilities
- Water utilities

Additional detail on the regulatory burden measurement assumptions and calculations is provided in Chapter 3 of the CBA report and some relevant assumptions are summarised in *Attachment E*.

5.3.5.1 Compliance costs

All of the options lead to minor ongoing administrative compliance costs for PFOS users due to record keeping and reporting to support certification (Option 2) or licensing (Options 3 and 4).

All the options lead to substantive compliance costs for PFOS users, associated with transitioning away from PFOS use and disposing of PFOS waste appropriately, as shown in Table 22.

Table 22. Compliance cost categories under each option

Cost	2	3	4
One-off costs for businesses transitioning away from PFOS			
Establishment costs for transition to known non-PFOS alternatives in the hard chromium plating, decorative chromium plating and plastics etching industries such as purchase and installation of systems and product trials	×	✓	✓
Appropriate destruction of fire fighting foam stocks and purchase of non-PFOS alternatives	✓	✓	✓
Ongoing costs for businesses transitioning away from PFOS			
Purchase price differential for non-PFOS alternatives in the hard chromium plating, decorative chromium plating and plastic etching industries	×	✓	✓
Ongoing costs for businesses continuing to use PFOS			
Certification for businesses importing PFOS	✓	×	×
Licensing for businesses using PFOS	×	✓	✓
Activities to increase recycling rates for X-ray photography	×	×	✓
Site cleanup, including collection and appropriate disposal of firewater, where PFOS-containing fire fighting foam are used	✓	✓	✓[128]
Sampling, analysis and appropriate disposal of PFOS waste in landfill (19.78 per cent) or destruction (0.22 per cent) of biosolids	✓	✓	✓

The compliance costs vary between industries depending on the costs of transitioning away from PFOS, including the purchase of alternatives to PFOS. The disposal and destruction costs for PFOS waste also vary depending on the type of waste and the treatment options available.

5.3.5.2 Delay costs

The options for regulation presented in this RIS are designed to avoid delay costs. The lead time for implementation means that certification and licensing systems would be fully operational by the time they are needed.

Under Option 2, once certification systems are in place, Australia would be able to provide certification to exporting countries within a few business days. Under Options 3 and 4, there would be no significant delay cost for obtaining licenses as businesses will have sufficient lead in time to implement system changes.

The status quo has significant potential delay costs as the Government is currently unable to provide certification, which could lead to an interruption in the supply of PFOS-containing imports.

5.3.5.3 Regulatory Burden Measurement (RBM)

Table 23 presents the overall results of the RBM for each option. Table 24 provides a breakdown of regulatory burden measurement by industry for each option. There are no community organisation or individual costs.

[128] Of limited relevance to Option 4, for a small number of non-compliant sites

Table 23. Regulatory burden measurement (RBM) table

Average annual regulatory costs (from business as usual) ($m)				
Change in Costs ($ m)	Business	Community	Individuals	Total
Option 1	0.00	0.00	0.00	**0.00**
Option 2	11.90	0.00	0.00	**11.90**
Option 3	11.89	0.00	0.00	**11.89**
Option 4	4.01	0.00	0.00	**4.01**

Table 24. Regulatory burden measurement (RBM) table by industry

Average annual regulatory costs (from business as usual) ($m)				
Change in Costs ($ m)	Option 1	Option 2	Option 3	Option 4
Hard chromium plating	0.00	0.24	0.25	0.20
Decorative chromium plating	0.00	0.10	0.07	0.07
Plastics etching[129]	0.00	0.00	0.04	0.04
X-ray photography[130]	0.00	0.00	0.00	0.06
Fire fighting	0.00	10.53	10.51	2.62
Water utilities	0.00	1.02	1.02	1.02
Total	**0.00**	**11.90**	**11.89**	**4.01**

5.3.6 Comparison of the options

5.3.6.1 Summary of PFOS emissions reduction

The projected reduction in annual PFOS emissions for each option is shown in Figure 7 and the cumulative emissions for each option are shown in Figure 8.

Although the annual emissions for the base case approach the annual emissions of the other options towards the end of the period, the total emissions for the base case over the twenty-year period are 25.74 tonnes, which is much higher than the emissions for the other options.

Options 2 to 4 would all significantly reduce the cumulative emissions of PFOS over the twenty-year period, compared with the base case. Option 4 achieved the maximum reduction in emissions to 0.62 tonnes, representing a reduction of 25.12 tonnes.

[129] The RBM cost for plastics etching under Option 2 is $815 per year.
[130] The RBM cost for X-ray photography under Options 2 and 3 is $1,630 per year.

Figure 7. Projected annual PFOS emissions by option (2017-18 to 2036-37)

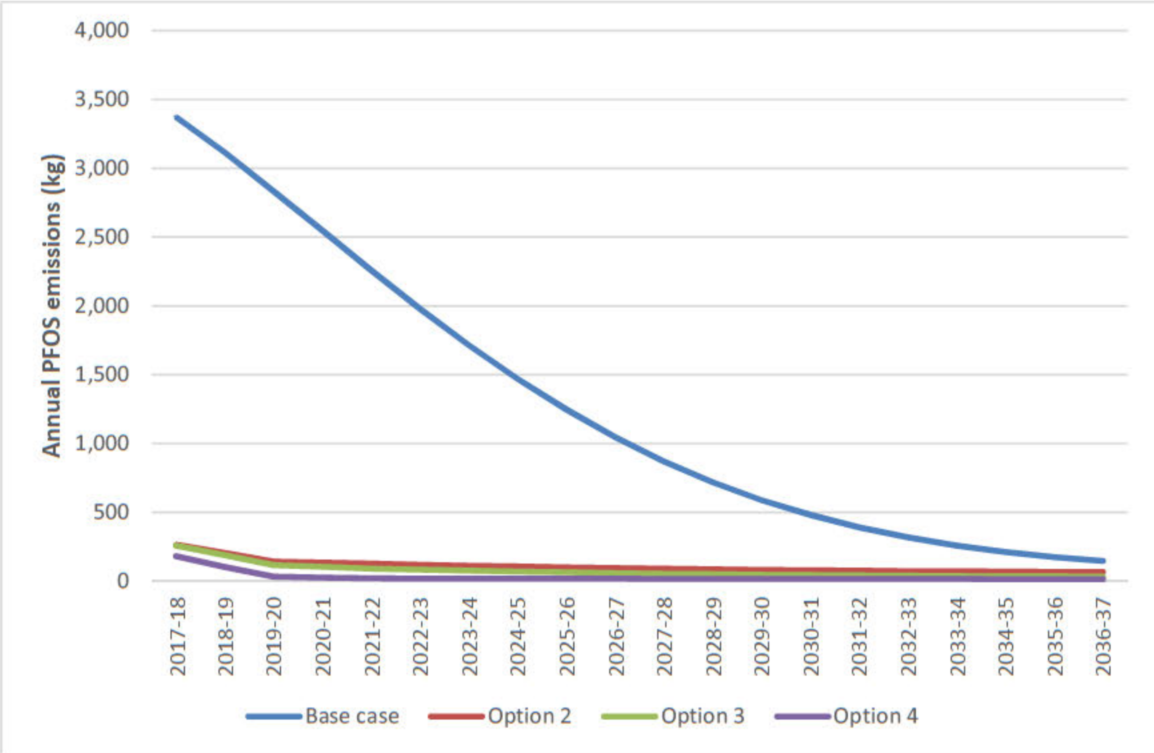
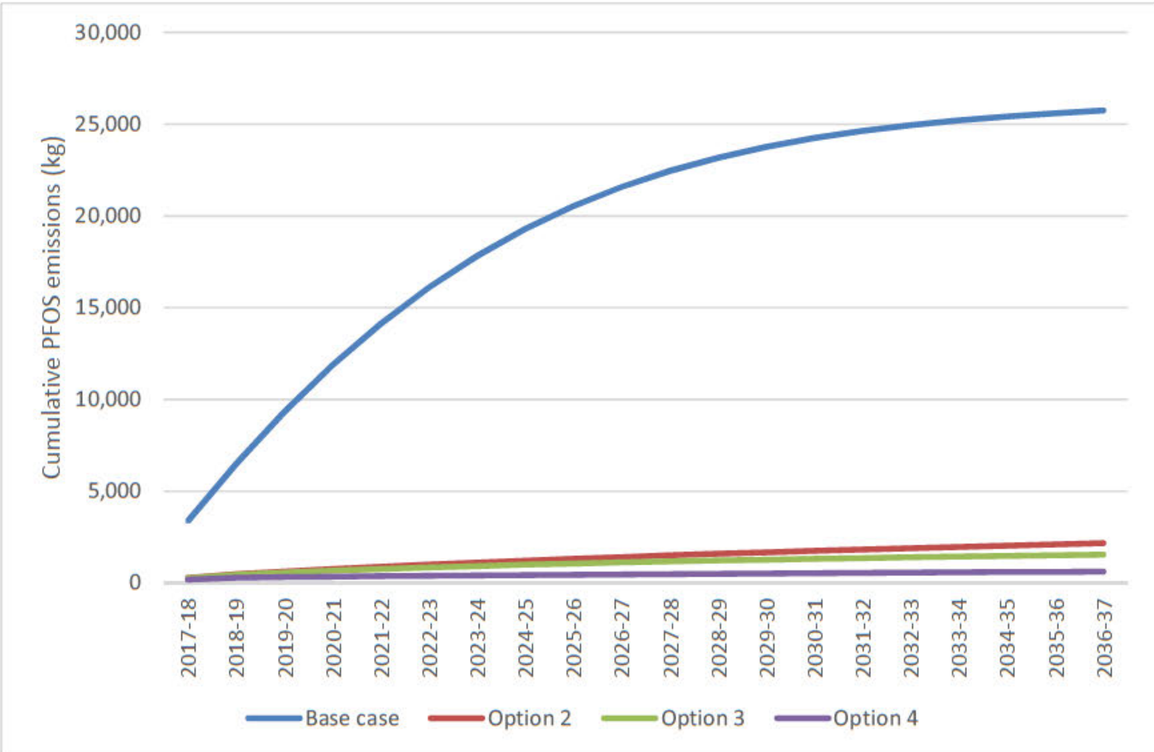


Figure 8. Projected cumulative PFOS emissions by option (2017-18 to 2036-37)



5.3.7 Summary of benefits

The analysis of options suggests that the highest net value to Australia is likely to come from Option 4. However, it is possible that information gathered during the consultation process for this RIS could change the analysis, including the ranking of options.

Table 25 summarises the financial impact analysis including financially quantified costs and benefits over the period 2017-18 to 2036-37 for each option. Option 1 is included as the base line used to determine the marginal costs and benefits for the other options, although it has no financial costs.

The benefits of each option are strongly influenced by the extent of reduction in PFOS wastes from fire fighting and whether these PFOS wastes are in the form of fire fighting foam or firewater. The waste management costs of PFOS-contaminated firewater and soil from the ongoing use of existing stocks significantly outweigh the cost of switching to alternatives. By contrast, if these existing stocks are destroyed before use, the overall costs are much lower. The comparative costs of waste disposal, including destruction of PFOS content, for different fire fighting materials are presented in Table 6. Under Option 1, because there is no consistent national standard for the disposal of fire fighting materials, most of the PFOS in fire fighting waste can eventually end up as PFOS emissions to the environment with ongoing high unquantifiable costs.

Although Option 4 presents a higher known financial cost than the base case presented in Option 1, it would avoid the risk under Option 1 of the ongoing high unquantifiable costs from PFOS emissions. The financial costs of the regulation options, including Option 4, arise from the implementation of the polluter pays principle, which is a core economic tool for managing the externality costs of environmental contamination.

It is important to note that the status quo of freedom from externality costs for businesses using PFOS is already changing rapidly, due to the trend to much more stringent state and territory regulation. There are also the considerable trade-related risks if Australia become one of the few countries where the supply of PFOS-related chemicals, articles, and manufactured products remained legal, and from interruptions to the supply of essential PFOS imports following ratification of the Stockholm Convention listing of PFOS by most countries.

Option 1 therefore provides no certainty that businesses using PFOS will be able to avoid high and unpredictable financial costs and other business risks.

The remaining options, Options 2 and 3, would deliver a significant proportion of the intangible and unquantifiable benefits of Option 4 but at a much higher cost. These options would also do little to reduce the risk of environmental costs, particularly new site contamination, due to accidental releases of PFOS.

Based on the information used in this analysis, Option 4 clearly delivers the highest net value for Australia. Table 25 summarises the cost benefit analysis (CBA) over 20 years (2017-18 to 2036-37) for each option.

Table 25. Financial impact - CBA (2017-18 to 2036-37)

		Option 1	Option 2	Option 3	Option 4
PFOS emissions over 20 years (tonnes)		25.74	2.17	1.54	0.62
Prevented emissions (tonnes)		0.00	23.57	24.21	25.12
Cost to prevent emissions ($/kg)		N/A	4276	4153	1542
Benefits ($m)					
No quantified financial benefits		0.00	0.00	0.00	0.00
Total Benefits		0.00	0.00	0.00	0.00
Costs ($m)					
Certification	Industry	0.00	1.42	0.00	0.00
	Government	0.00	2.23	0.00	0.00
Regulation and licensing	Industry	0.00	0.00	0.26	0.18
	Government	0.00	0.00	2.09	3.38
Cost of alternatives	Industry	0.00	7.82	9.80	22.86
	Government	0.00	0.00	0.00	0.00
Waste management	Industry	0.00	81.19	80.24	4.14
Infrastructure	Industry	0.00	7.74	7.74	7.74
	Government	0.00	0.40	0.40	0.45
Total Costs	Industry	0.00	98.17	98.05	34.91
	Government	0.00	2.62	2.48	3.84
	Total	0.00	100.80	100.53	38.75

In order of decreasing financial net benefit, the ranking of options is: Option 1, Option 4, Option 3 and Option 2. As previously discussed, however, Option 1 carries significant unquantifiable risks and costs due to the environmental and potential human impacts of PFOS exposure. Consequently, Option 1 is not considered viable. The unquantifiable benefits reinforce the selection of Option 4 as the preferred option, as shown in Table 26.

Table 26. Ranking of key qualitative benefits by option

Qualitative benefits over 20 years	Option 1	Option 2	Option 3	Option 4
Prevented emissions (tonnes)	0.00	23.57	24.21	25.12
Cost to prevent emissions ($/kg)	N/A	4276	4153	1542
Health benefits	4	3	2	1
Environment benefits	4	3	2	1
Avoided legal liability	4	3	2	1
Avoided supply uncertainty	4	3	=1	=1
Overall ranking	4	3	2	1

Option 4 is the most cost-effective option as it has the lowest cost along with the highest decrease in PFOS emissions. It is also the option most likely to provide a positive net benefit overall. Importantly, most of the financial impacts of Option 4 arise from the requirement for environmentally sound disposal of PFOS-containing fire fighting foam, including destruction of its PFOS content where necessary, and this already has widespread support from the fire protection industry and state and territory governments.

5.4 Conclusion

Analysis of options suggests that the highest net value to Australia is likely to come from Option 4. Table 25 summarises the financial impact analysis including financially quantified costs and benefits over the period 2017-18 to 2036-37 for each option. The benefits of each option are strongly influenced by the extent of reduction in PFOS wastes from fire fighting and whether these PFOS wastes are in the form of fire fighting foam or firewater. The waste management costs of PFOS-contaminated firewater and soil from the ongoing use of existing stocks significantly outweigh the cost of switching to alternatives. By contrast, if these existing stocks are destroyed before use, the overall costs are much lower. While Option 1 has no financial costs, because there is no consistent national standard for the disposal of fire fighting materials, under this option most of the PFOS in fire fighting waste can eventually end up as PFOS emissions to the environment with ongoing high unquantifiable costs.

Although Option 4 presents a higher known financial cost than the base case presented in Option 1, it would avoid the risk under Option 1 of the ongoing high unquantifiable costs from PFOS emissions. The financial costs of the regulation options, including Option 4, arise from the implementation of the polluter pays principle, which is a core economic tool for managing the externality costs of environmental contamination.

The projected reduction in annual PFOS emissions for each option is shown in Figure 7 and the cumulative emissions for each option are shown in Figure 8. Total emissions for the base case over the twenty-year period are 25.74 tonnes, which is much higher than the emissions for the other options. Options 2 to 4 would all significantly reduce the cumulative emissions of PFOS over the twenty-year period - Option 4 achieved the maximum reduction in emissions to 0.62 tonnes (representing a reduction of some 25.12 tonnes).

From a cost-effectiveness perspective, Option 4 is estimated to achieve the emission reductions at lowest cost, at $1,542.34 per kilogram reduction in PFOS. In comparison, Option 2 would cost $4,276.00/kg and Option 3 $4,152.85/kg. The merit of this comparison is that it adds further confidence to the conclusion that Option 4 delivers the highest net value, but does not involve judgements on the valuation of benefits to the environment and human health.

5.4.1 Sensitivity analysis of the CBA results

As outlined above, a range of assumptions underpin the CBA modelling. To ensure that the results of modelling are robust, established practice is to undertake additional analysis on variables with high uncertainty and a potentially significant influence on results. This is known as sensitivity analysis because it helps to test the sensitivity of the results to changes in the variables. If changing these key variables switches the rankings of the results (e.g. if Option 3 now gives a higher result than Option 4), then the assumptions may need to be re-examined and the results more carefully qualified.

Sensitivity analysis was undertaken to examine whether changes in the discount rate would result in a shift between the relative rankings of the net benefits for the policy options presented in this RIS. Table 27 illustrates the results of this analysis for discount rate values ranging between 3 per cent and 10 per cent. The ranking of the policy options does not switch in response to these changes. Therefore the results are robust in terms of changes to discount rates.

Table 27. Sensitivity analysis for changes to the discount rate (PV of total costs, $m)

	Option 1	Option 2	Option 3	Option 4
Discount Rate - 3%	0.00	126.4	125.9	46.3
Discount Rate - 7%	0.00	100.8	100.5	38.7
Discount Rate - 10%	0.00	86.9	86.7	34.7

It is possible that the consultation process will yield feedback on the relative uncertainties and influence of the other key variables used in the CBA modelling. Additional sensitivity analysis will be completed if required.

6. HOW WILL AUSTRALIA'S PHASE OUT OF PFOS BE IMPLEMENTED?

6.1 Legislative options for implementation

The Government will work with states and territories to examine legislative approaches that could be used to implement the options for action (Options 2 to 4). Key considerations will include the legislative design, coverage and selecting the right policy instruments to achieve the objectives.

States and territories may use existing legislation to implement these options, or certain aspects of the options. All jurisdictions already have a legislative framework for environmental protection. Some jurisdictions may also need to develop new legislation or amend existing legislation to fully implement the selected option. Matters covered by state and territory legislation could include requirements for the licensing of facilities and sites using PFOS, the storage, disposal and clean-up of PFOS wastes (including destruction) and bans on PFOS releases.

Compliance monitoring, investigations, and prosecutions for breaches of these regulatory measures would be carried out by those authorised to do so under each jurisdiction's legislation. Each jurisdiction would set and enforce penalties for breaches of its regulatory measures (and so the penalties would likely differ in each jurisdiction).

Another approach could be to leverage existing Commonwealth legislation such as the *Product Stewardship Act 2011* (the PS Act). The PS Act establishes a national product stewardship framework to manage the environmental, health, and safety impacts of products, and the impacts associated with their disposal. Regulations made under the PS Act could prohibit, limit, restrict or otherwise affect the manufacture, import, export, distribution or use of PFOS. However, depending on the option selected, the scope for regulating PFOS under the PS Act may be limited.

The Department is also working more broadly with states and territories to progress nationally consistent management of chemicals in the environment. As part of this, a national framework could be put in place to establish management controls throughout the full lifecycle of chemicals of concern, including PFOS. Should this work lead to new Commonwealth legislation, it could provide an effective framework to control and manage chemicals and hazardous substances, including import, export, manufacture, use, storage, emission, release, disposal and end of life management, including destruction where necessary.

This approach could be an efficient way to implement Australia's obligations under the Stockholm Convention, including for PFOS and any subsequent chemical listings. It could also support implementation of:

- the national standard for the environmental risk management of industrial chemicals, agreed in principle by all environment ministers in July 2015
- the reform of the NICNAS
- Australia's obligations under other international environmental agreements such as the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous

Chemicals and Pesticides in International Trade and the Minamata Convention on Mercury.

A number of issues will require further consideration and consultation, including with states and territories, to establish the preferred implementation approach. These include:

- Whether the legislation or regulations are likely to be suitable to meet obligations for new chemicals that may be added to the Stockholm Convention in the future.
- The appropriate roles and responsibilities of the Commonwealth, states and territories.
- Whether the approach achieves an appropriate level of national consistency for the proposed outcomes.
- Policy tools such as compliance, enforcement, monitoring and investigative powers, cost recovery, and establishment of a technical advisory body.

6.2 Requirements for management of PFOS wastes

All of the options for action (Options 2-4) will require that Australia:

- is able to identify wastes containing PFOS above the low content level of 50 mg/kg established under the Stockholm Convention.
- regulates to require the use of appropriate disposal methods for these wastes, including destruction where necessary.

The Department has consulted with states and territories, researchers and industry on the existing options for safe destruction of PFOS-containing waste. Appropriate technologies, subject to the facility meeting requirements for licensing and emissions monitoring, include high temperature incinerators, incineration in cement kilns and plasma arc.[131] Research is also ongoing into remediation technologies able to stabilise PFOS or separate PFOS from bulk wastes so that the bulk material is suitable for disposal as general waste.

In principle, the best choice of destruction technology depends on the material being destroyed. However, affordable options for PFOS waste disposal are not universally available, particularly for high volumes of waste. These capacity limitations mean that it could take a long time to destroy all existing stocks of PFOS-containing products and wastes, particularly fire fighting foams.

State and territory governments and the waste industry may identify opportunities to work together to increase PFOS waste disposal capacity. For example, it could be possible to alter the licensing requirements for existing facilities, such as cement kilns, to allow for the safe destruction of PFOS waste.

[131] Plasma arc waste disposal involves heating waste to a high temperature, melting it such that the organic components are converted to gas and the inorganic components are deposited in a solid form, thus no longer having any POP characteristics.

7. CONSULTATION

The Department is releasing this RIS to inform consultation with all stakeholders including state, territory and local governments, industry and the wider community. The feedback from consultation will inform the development of a final RIS for consideration by the Government.

Comments are sought on the suggested options for government action, the data and assumptions underpinning those options and the data gaps identified in the impact analysis. Stakeholder feedback will be particularly important to identify any implementation barriers or unintended consequences of the proposed options that may not be considered in this RIS.

Information is sought on:

- The capacity of industry to achieve the proposed PFOS phase outs, process improvements and waste disposal requirements, including destruction
- Additional information that would help to substantiate, or refine the accuracy of, the analysis of costs and benefits
- For fire fighting, information on the current import, use, storage and stocks of PFOS-containing fire fighting foams, including use in shipping
- For chromium plating, information on the current import, use, storage and stocks of PFOS and, where it is used, the proportion of systems that are open-loop as opposed to closed-loop
- For X-ray photography and other medical uses, information on the current extent of use and service life of devices, and any data on non-PFOS alternatives or replacement technologies that would inform cost benefit analysis calculations
- For aviation hydraulic fluids, information on the current use of PFOS-containing aviation hydraulic fluids in Australia, if any, including any data that would inform cost benefit analysis calculations
- For pesticides, information on any current or historical use of PFOS-substances as surfactants or other constituents in Australia
- Implementation mechanisms for biosolids and leachate management and the feasibility of the proposed approaches
- The appropriate division of implementation responsibility across the Commonwealth, states and territories and, if appropriate, local government
- Information on whether any complex PFOS derivatives listed in *Attachment A* are currently used in Australia.

7.1 Where to get more information

The Department will be holding public workshops in each state and territory capital city during the consultation period. You are invited to register your interest in attending a workshop on our website.

The background analysis supporting this RIS is listed in *Attachment D*.

Email enquiries may be sent to PFASstandards@environment.gov.au.

7.2 How to make a submission

The Department invites submissions to the options presented in this RIS from industry groups, businesses, members of the community, state, territory and local governments and any other interested party.

Responses received will inform the final Regulation Impact Statement which is expected to be considered by the Government in the first half of 2018.

Each submission will be published on the Department's website. Copyright of submissions will reside with the author(s) and not the Government.

Submissions should be lodged electronically, via the email address below. Alternatively they may be sent to the postal address provided below.

All submissions must be received by close of business **Monday, 26 February 2018.**

Email: PFASstandards@environment.gov.au

Post: PFAS Standards Section
Department of the Environment and Energy
GPO BOX 787
CANBERRA ACT 2601

7.3 Privacy Statement

The Department is releasing this RIS for consultation, and to provide the opportunity for interested parties to comment on the options proposed. Personal information provided will be used accordingly:

- to contact you in relation to matters raised in your submission or to invite you to participate in subsequent activities relating to the treaty-making process for PFOS
- where a submission raises a matter relevant to the portfolio interests of another agency, such that it is appropriate to disclose your personal information to that agency

Personal information included in your submission may also be disclosed in subsequent Departmental publications that are relevant to the portfolio interests of this Department. The Department's privacy policy contains information about how to access personal information, how to make a request for correction of personal information and how to make a complaint in relation to the handling of personal information. For a copy of the Department's Privacy Policy, please contact 02 6274 2131.

7.4 Confidentiality Statement

It is preferred that submissions do not contain confidential elements to allow transparent review and decision-making processes.

All submissions will be treated as public documents. Public submissions may be published in full on the Department's website, including any personal information of authors and / or other third parties in the submission.

If a submission contains personal information about any person who is not an author of the submission, please indicate on the cover sheet if they have not consented to the publication of this information.

Any requests under the *Freedom of Information Act 1982* for access to a submission will be determined in accordance with that Act.

ATTACHMENTS

Attachment A

List of PFOS-related substances that have been, or may have been, used in Australia

Table A1 lists the PFOS-related substances, including PFOS, PFOSF, and other PFOS-related chemicals that are publicly listed in the Australian Inventory of Chemical Substances (AICS) as chemicals available for industrial use in Australia.[132] Table A2 lists other PFOS-related substances, covered by the Stockholm Convention listing of PFOS, that are not publicly listed in the AICS. See OECD Environment Directorate (2007) for a comprehensive list of known PFOS-related chemicals, including those thought not to have been used in Australia. Where available, the Chemical Abstracts Service (CAS) Registry Number for each substance is hyperlinked to further information provided by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS).[133, 134]

Table A1. PFOS-related substances on the AICS

CAS Registry Number	Chemical Name
127133-66-8	2-Propenoic acid, 2-methyl-, polymers with butyl methacrylate, lauryl methacrylate and 2-[methyl[(perfluoro-C4-8-alkyl)sulfonyl]amino]ethyl methacrylate
161074-58-4	Fatty acids, C18-unsatd., trimers, reaction products with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8 heptadecafluoro-N-(2-hydroxyethyl)-N-methyl-1-octanesulfonamide, 1,1,2,2,3,3,4,4,4-nonafluoro-N-(2-hydroxyethyl)-N-methyl-1-butanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-N-(2-hydroxyethyl)-N-methyl-1-heptanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluoro-N-(2-hydroxyethyl)-N-methyl-1-hexanesulfonamide and 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-N-(2-hydroxyethyl)-N-methyl-1-pentanesulfonamide
1652-63-7	1-Propanaminium, 3-[[(heptadecafluorooctyl)sulfonyl]amino]-N,N,N-trimethyl-, iodide
1691-99-2	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-
185630-90-4	9-Octadecenoic acid (Z)-, reaction products with N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-1-octanesulfonamide
192662-29-6	Sulfonamides, C4-8-alkane, perfluoro, N-[3-(dimethylamino)propyl], reaction products with acrylic acid
2250-98-8	1-Octanesulfonamide, N,N',N''-[phosphinylidynetris(oxy-2,1-ethanediyl)]tris[N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-

[132] See https://www.nicnas.gov.au/chemical-inventory-AICS for information about the AICS.
[133] See https://www.cas.org/content/chemical-substances/faqs for information about the CAS Registry.
[134] See https://www.nicnas.gov.au/chemical-information/imap-assessments for information about NICNAS and the Inventory Multi-tiered Assessment and Prioritisation (IMAP) process for assessing existing chemicals.

24448-09-7	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-N-methyl-
253682-96-1	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, reaction products with succinic anhydride monopolyisobutylene derivs.
2795-39-3	1-Octanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, potassium salt
29081-56-9	1-Octanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, ammonium salt
29117-08-6	Poly(oxy-1,2-ethanediyl), .alpha.-[2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl]-.omega.-hydroxy-
29457-72-5	1-Octanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, lithium salt
2991-51-7	Glycine, N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]-, potassium salt
30381-98-7	1-Octanesulfonamide, N,N'-[phosphinicobis(oxy-2,1-ethanediyl)]bis[N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, ammonium salt
306973-47-7	Sulfonamides, C4-8 -alkane, perfluoro, N-(hydroxyethyl)- N-methyl, reaction products with 12-hydroxystearic acid and 2,4 -TDI, ammonium salts
306975-56-4	Propanoic acid, 3-hydroxy- 2-(hydroxymethyl) -2-methyl-, polymer with 2-ethyl -2-(hydroxymethyl) -1,3-propanediol and N, N', 2-tris(6-isocyanatohexyl) imidodicarbonic diamide reaction products with N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8 heptadecafluoro-N-(2-hydroxyethyl)-1-octanesulfonamide and N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-N-(2-hydroxyethyl)-1-heptanesulfonamide, compds. with triethylamine
307-35-7	1-Octanesulfonyl fluoride, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-
31506-32-8	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-methyl-
37338-48-0	Poly[oxy(methyl-1,2-ethanediyl)], .alpha.-[2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl]-.omega.-hydroxy-
376-14-7	2-Propenoic acid, 2-methyl-, 2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl ester
38006-74-5	1-Propanaminium, 3-[[(heptadecafluorooctyl)sulfonyl]amino]-N,N,N-trimethyl-, chloride
3820-83-5	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-[2-(phosphonooxy)ethyl]-
40630-61-3	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N,N-bis(2-hydroxyethyl)-
423-82-5	Acrylic acid, ester with N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-1-octanesulfonamide
56773-42-3	Ethanaminium, N,N,N-triethyl-, salt with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-1-octanesulfonic acid (1:1)

57589-85-2	Benzoic acid, 2,3,4,5-tetrachloro-6-[[[3-[[(heptadecafluorooctyl)sulfonyl]oxy]phenyl]amino]carbonyl]-, monopotassium salt
594864-11-6	2-Propenoic acid, butyl ester, polymer with 2[butyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl 2-propenoate and 2-methylpropyl 2-propenoate
67939-88-2	1-Octanesulfonamide, N-[3-(dimethylamino)propyl]-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, monohydrochloride
67969-69-1	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-[2-(phosphonooxy)ethyl]-, diammonium salt
68081-83-4	Carbamic acid, (4-methyl-1,3-phenylene)bis-, bis[2-[ethyl[(perfluoro-C4-8-alkyl)sulfonyl]amino]ethyl] ester
68227-96-3	2-Propenoic acid, butyl ester, telomer with 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-propenoate, 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, .alpha.-(2-methyl-1-oxo-2-propenyl)-.omega.-hydroxypoly(oxy-1,4-butanediyl), .alpha.-(2-methyl-1-oxo-2-propenyl)-.omega.-[(2-methyl-1-oxo-2-propenyl)oxy]poly(oxy-1,4-butanediyl), 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate,2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate and 1-octanethiol
68298-11-3	1-Propanaminium, 3-[[(heptadecafluorooctyl)sulfonyl](3-sulfopropyl)amino]-N-(2-hydroxyethyl)-N,N-dimethyl-, hydroxide, inner salt
68298-62-4	2-Propenoic acid, 2-[butyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl ester, telomer with 2-[butyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, methyloxirane polymer with oxirane di-2-propenoate, methyloxirane polymer with oxirane mono-2-propenoate and 1-octanethiol
68298-78-2	2-Propenoic acid, 2-methyl-, 2-[[[[5-[[[2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethoxy]carbonyl]amino]-2-methylphenyl]amino]carbonyl]oxy]propyl ester, telomer with butyl 2-propenoate, 2-[[[[5-[[[2-[ethyl[(nonafluorobutyl)sulfonyl]amino]ethoxy]carbonyl]amino]-2-methylphenyl]amino]carbonyl]oxy]propyl 2-methyl-2-propenoate, 2-[[[[5-[[[2-[ethyl[(pentadecafluoroheptyl)sulfonyl]amino]ethoxy]carbonyl]amino]-2-methylphenyl]amino]carbonyl]oxy]propyl 2-methyl-2-propenoate, 2-[[[[5-[[[2-[ethyl[(tridecafluorohexyl)sulfonyl]amino]ethoxy]carbonyl]amino]-2-methylphenyl]amino]carbonyl]oxy]propyl 2-methyl-2-propenoate, 2-[[[[5-[[[2-[ethyl[(undecafluoropentyl)sulfonyl]amino]ethoxy]carbonyl]amino]-2-methylphenyl]amino]carbonyl]oxy]propyl 2-methyl-2-propenoate, 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-propenoate, 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate and 1-octanethiol

68299-39-8	2-Propenoic acid, 2-methyl-, 4-[[(heptadecafluorooctyl)sulfonyl]methylamino]butyl ester, telomer with butyl 2-propenoate, 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-propenoate, 4-[methyl[(nonafluorobutyl)sulfonyl]amino]butyl 2-methyl-2-propenoate, 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, .alpha.-(2-methyl-1-oxo-2-propenyl)-.omega.-hydroxypoly(oxy-1,4-butanediyl), .alpha.-(2-methyl-1-oxo-2-propenyl)-.omega.-[(2-methyl-1-oxo-2-propenyl)oxy]poly(oxy-1,4-butanediyl), 4-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]butyl 2-methyl-2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 4-[methyl[(tridecafluorohexyl)sulfonyl]amino]butyl 2-methyl-2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate, 4-[methyl[(undecafluoropentyl)sulfonyl]amino]butyl 2-methyl-2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate and 1-octanethiol
68329-56-6	2-Propenoic acid, eicosyl ester, polymer with 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-propenoate, hexadecyl 2-propenoate, 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate and octadecyl 2-propenoate
68555-90-8	2-Propenoic acid, butyl ester, polymer with 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-propenoate, 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate and 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl2-propenoate
68555-91-9	2-Propenoic acid, 2-methyl-, 2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl ester, polymer with 2-[ethyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[ethyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[ethyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[ethyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate and octadecyl 2-methyl-2-propenoate
68555-92-0	2-Propenoic acid, 2-methyl-, 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl ester, polymer with 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate and octadecyl 2-methyl-2-propenoate
68568-77-4	2-Propenoic acid, 2-methyl-, 2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl ester, polymer with 2-chloro-1,3-butadiene, 2-[ethyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[ethyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[ethyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate and 2-[ethyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate

68586-14-1	2-Propenoic acid, 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl ester, telomer with 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, .alpha.-(2-methyl-1-oxo-2-propenyl)-.omega.-hydroxypoly(oxy-1,2-ethanediyl), .alpha.-(2-methyl-1-oxo-2-propenyl)-.omega.-[(2-methyl-1-oxo-2-propenyl)oxy]poly(oxy-1,2-ethanediyl), 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate and 1-octanethiol
68608-13-9	Sulfonamides, C4-8-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with 1,3-diisocyanatomethylbenzene polymer
68608-14-0	Sulfonamides, C4-8-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with 1,1'-methylenebis[4-isocyanatobenzene]
68649-26-3	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-, reaction products with N-ethyl-1,1,2,2,3,3,4,4,4-nonafluoro-N-(2-hydroxyethyl)-1-butanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-N-(2-hydroxyethyl)-1-heptanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluoro-N-(2-hydroxyethyl)-1-hexanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,5-undecafluoro-N-(2-hydroxyethyl)-1-pentanesulfonamide, polymethylenepolyphenylene isocyanate and stearyl alcohol
68797-76-2	2-Propenoic acid, 2-methyl-, 2-ethylhexyl ester, polymer with 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-propenoate, 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate and oxiranylmethyl 2-methyl-2-propenoate
68867-60-7	2-Propenoic acid, 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl ester, polymer with 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate and .alpha.-(1-oxo-2-propenyl)-.omega.-methoxypoly(oxy-1,2-ethanediyl)
68867-62-9	2-Propenoic acid, 2-methyl-, 2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl ester, telomer with 2-[ethyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[ethyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[ethyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 2-[ethyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-methyl-2-propenoate, 1-octanethiol and .alpha.-(1-oxo-2-propenyl)-.omega.-methoxypoly(oxy-1,2-ethanediyl)
68891-96-3	Chromium, diaquatetrachloro[.mu.-[N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]glycinato-O1:O1']]-.mu.-hydroxybis[2-methylpropanol]di-
68909-15-9	2-Propenoic acid, eicosyl ester, polymer with branched octyl 2-propenoate, 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-propenoate, 2-

	[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate, octadecyl 2-propenoate and .alpha.-(1-oxo-2-propenyl)-.omega.-methoxypoly(oxy-1,2-ethanediyl)
68958-61-2	Poly(oxy-1,2-ethanediyl), .alpha.-[2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl]-.omega.-methoxy-
70225-14-8	1-Octanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, compound with 2,2′-iminobis[ethanol] (1:1)
70776-36-2	2-Propenoic acid, 2-methyl-, octadecyl ester, polymer with 1,1-dichloroethene, 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-propenoate, N-(hydroxymethyl)-2-propenamide, 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl2-propenoate and 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate
70900-40-2	2-Propenoic acid, 2-methyl-, 2-[[[[5-[[[4-[[(heptadecafluorooctyl)sulfonyl]methylamino]butoxy]carbonyl]amino]-2-methylphenyl]amino]carbonyl]oxy]propyl ester, telomer with butyl 2-propenoate, 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-ropenoate, 2-[[[[2-methyl-5-[[[4-[methyl[(nonafluorobutyl)sulfonyl]amino]butoxy]carbonyl]amino]phenyl]amino]carbonyl]oxy]propyl 2-methyl-2-propenoate, 2-[[[[2-methyl-5-[[[4-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]butoxy]carbonyl]amino]phenyl]amino]carbonyl]oxy]propyl 2-methyl-2-propenoate, 2-[[[[2-methyl-5-[[[4-[methyl[(tridecafluorohexyl)sulfonyl]amino]butoxy]carbonyl]amino]phenyl]amino]carbonyl]oxy]propyl 2-methyl-2-propenoate, 2-[[[[2-methyl-5-[[[4-[methyl[(undecafluoropentyl)sulfonyl]amino]butoxy]carbonyl]amino]phenyl]amino]carbonyl]oxy]propyl 2-methyl-2-propenoate, 2-[methyl[(nonafluorobutyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(tridecafluorohexyl)sulfonyl]amino]ethyl 2-propenoate, 2-[methyl[(undecafluoropentyl)sulfonyl]amino]ethyl 2-propenoate and 1-octanethiol
91081-99-1	Sulfonamides, C4-8-alkane, perfluoro, N-(hydroxyethyl)-N-methyl, reaction products with epichlorohydrin, adipates (esters)
92265-81-1	Ethanaminium, N,N,N-trimethyl-2-[(2-methyl-1-oxo-2-propenyl)oxy]-, chloride, polymer with 2-ethoxyethyl 2-propenoate, 2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl 2-propenoate and oxiranylmethyl 2-methyl-2-propenoate
94133-90-1	1-Propanesulfonic acid, 3-[[3-(dimethylamino)propyl][(heptadecafluorooctyl)sulfonyl] amino]-2-hydroxy-, monosodium salt
94313-84-5	Carbamic acid, [5-[[[2-[[(heptadecafluorooctyl)sulfonyl]methylamino]ethoxy]carbonyl]amino]-2-methylphenyl]-, 9-octadecenyl ester, (Z)-

Table A2. PFOS-related substances not publicly listed in the AICS that may have been used in Australia including for research or other specialised purposes

CAS Registry Number	Chemical Name
1763-23-1	1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-1-octanesulfonic acid
251099-16-8	1-Decanaminium, N-decyl-N,N-dimethyl-, salt with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-1-octanesulfonic acid (1:1)
4151-50-2	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-

Attachment B

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Attachment C

Regulatory Burden Measurement Framework Costing

General Assumptions

The Regulatory Burden Measure (RBM) calculation is based on the report "Cost benefit analyses relating to the ratification of the amendments to list four chemicals on the Stockholm Convention" prepared by Marsden Jacob Associates with input from the Department.

The RBM focuses on the costs to industry incurred as a result of new government action under each option. The industries which will be impacted include:

- Hard chromium plating
- Decorative chromium plating
- Plastics etching
- X-ray photography
- Fire fighting (major hazard facilities)
- Water utilities.

The first five industries are current PFOS using industries, while the costs of monitoring and treating PFOS-contaminated biosolids released from waste infrastructure are calculated as the costs of the water utilities industry.

Significant transition costs have been identified for industry if listing of PFOS under the Stockholm Convention (Options 3 and 4) is ratified. Costs apply to hard chromium plating, decorative chromium plating, plastics etching, photography and major hazard facility fire fighting activities. It is noted that the timing of these transition costs – at the start of the assessment period – inflates the regulatory burden figure relative to the longer analysis timeframe for the CBA.

The administrative compliance cost identified for PFOS relates to monitoring and reporting activities for import certification (Option 2) and licensing of use (Options 3 and 4).

All regulatory costs are estimated (in 2014-15 dollars) as annual average of a ten year period beginning at the financial year 2017-18.

Explanation of options and relevant assumptions

Option 1 – No new policy intervention	**N/A**

Under this option:

- Use of PFOS would continue, including use of existing stockpiles.
- Wastes containing PFOS would not have specific controls.
- The Australia Government would not ratify the PFOS listing in the Stockholm Convention.
- The Australian Government would be unable to provide certification of PFOS management to exporting Parties that would allow it to continue to receive imports.
- Future PFOS imports may stop, negatively impacting importing businesses such as chrome platers.

- There would be continuing inconsistency in management of PFOS across Australian jurisdictions.
- There would be potential for further contamination as a result of ongoing use, increasing contingent liability for industry users and Australian governments.

It has been assumed that there are no costs to business under this option. A number of business-as-usual costs under this option (such as the costs for the disposal of chromium VI sludges to comply with existing regulatory requirements, or business choices to pay for the destruction of PFOS-containing aqueous film forming foam (fire fighting foam) in the absence of regulation requiring this) have not been quantified.

Option 2 – Do not ratify, but implement certification requirements	**$11,896,756 p.a.**

Under this option Australia would not ratify the listing of PFOS in the Stockholm Convention 2009 amendment but would implement changes to improve management of PFOS releases from use and waste disposal to meet certification requirements under the Stockholm Convention. This will ensure continued supply of PFOS to industry. All current uses of PFOS would continue under this option but businesses that import PFOS products and articles will only be able to do so once the Australian Government has provided certification for the intended use.

Costs for affected industries under this option include a number of compliance and administrative costs. The majority of certification costs would be incurred by government although there is likely to be a small cost to businesses in providing supporting information to the process and waste compliance monitoring. The certification process itself would be planned and implemented in a way that avoids delays to normal business operation. Therefore no delay costs would occur.

Hard chromium plating

For the hard chromium plating industry, the regulatory costs include costs of reporting and record keeping activities related to ongoing annual costs of import certification ($815 per business for monitoring and reporting), process improvement ($209 per business per year for increased costs of rinsing) and waste management costs ($10,659 per business used for transport and destruction of sludge).

Decorative chromium plating

For the decorative chromium plating industry, one cost is identified - import certification. While certification is largely a government process, it is estimated that the monitoring and reporting requirement for business would cost $815 per business.

Plastics etching

One cost relating to import certification is identified. While certification is largely a government process, it is estimated that the monitoring and reporting requirement for business would cost $815 per business.

Photography

Costs related to import certification are calculated to be $815 per business (for monitoring and reporting).

Fire fighting (use of fire fighting foams, principally at major hazard facilities)

The costs are identified as:

- import certification ($815 per business for monitoring and reporting)
- site clean-up costs estimated as $830,853 per site which applies to sites that use up existing fire fighting foams stocks
- waste management costs for disposal of contaminated fire water of $6,542 per kilogram of PFOS
- destruction of unwanted or expired fire fighting foam stocks of $448 per kilogram of PFOS
- replacement of fire fighting foams with non-PFOS alternatives estimated as $418 per kilogram.

Across the industries, the regulatory costs are:

- *Certification-related costs:* Costs of waste compliance monitoring and staff time for reporting to support annual PFOS import certification by the Australian Government. The cost would be incurred by all users of PFOS and is estimated at $139,100 per annum.
- *Cost of alternatives:* Costs of $955,335 per annum for appropriate disposal and replacement of PFOS-containing foams used in fire fighting.
- *Waste management (hard chromium plating):* Ongoing costs for process improvement and waste management in the hard chromium plating industry are estimated at $222,924 per annum.
- *Waste management (fire fighting):* Site clean-up and waste management costs for waste water where PFOS containing foams continue to be used in fire fighting are estimated at $9,557,501 per annum.
- *Waste management (biosolids released from waste infrastructure):* Water utilities industry costs for the monitoring and treatment of biosolids are $1,021,895 per annum.

Option 3 – Ratify and register permitted uses	**$11,888,878 p.a.**

Under this option Australia will ratify the listing of PFOS and register for acceptable purposes and specific exemptions for all currently identified uses. It is not envisaged that there would be an immediate ban for any current uses as all known uses in Australia are permitted. This option is expected to lead to a gradual reduction in existing PFOS stocks, particularly fire fighting foams, through continued use.

Costs for affected industries under this option include the following compliance and administrative costs. The licensing process would be planned in advance and implemented in a way that avoids delays to normal business operation. Therefore no delay costs would occur.

Hard chromium plating

Under this option, it is assumed that half of current businesses using PFOS choose to transition to PFOS alternatives over the first five years while the other half of businesses will adopt a closed loop system and continue to use PFOS-containing products. For the businesses that transition away from PFOS containing products, three establishment costs are identified:

- non-PFOS system establishment costs spread across years 2 to 5 ($2,090 per business comprising capital expenditure on equipment)
- transition costs spread across years 2 to 5 ($2,090 per business comprising operational expenditure to update management practices and technical knowledge
- non-PFOS product trial ($13,064 total for the hard chromium plating industry, representing half of a cost shared with government)

There is also an ongoing cost for non-PFOS alternatives ($10,346 per business per year).

For the businesses that do not transition away from PFOS containing products, but adopt a closed loop system, three ongoing costs are identified: licensing of use ($815 per business per year comprising monitoring and reporting)

- process improvement ($209 per business per year for increased costs of rinsing)
- waste management costs (including transport and destruction costs of $10,659 per business).

Decorative chromium plating

For all decorative chromium plating businesses, three establishment costs are identified:

- non-PFOS system establishment costs spread across years 2 to 5 ($2,090 per business comprising capital expenditure on equipment)
- transition costs spread across years 2 to 5 ($2,090 per business comprising operational expenditure to update management practices and technical knowledge)
- non-PFOS product trial ($13,064 total for the hard chromium plating industry, representing half of a cost shared with government).

In addition to these establishment costs one ongoing cost is identified for all the businesses that are yet to transition to alternatives until year 5 of the analysis, after which it is assumed that use ceases as all the local industry has moved to alternative products:

- licensing of use ($815 per business per year comprising monitoring and reporting).

Plastics etching

Two establishment costs are identified for plastics etching that apply to the one business assumed to still be using PFOS in Australia:

- non-PFOS system establishment costs of $5,225 in year 2
- transition costs of $2,090 per business in year 2.

In addition ongoing costs are identified for non-PFOS alternatives at a total of $40,759 per annum after year 1 of the analysis.

Photography

Under this option, the continued importation and use of PFOS-based photographic material entails a small industry cost of $1,630 per year ($815 per business for two businesses) comprising monitoring and reporting.

Fire fighting

The regulatory burden for fire fighting activities at major hazard facilities and sites with dangerous goods (e.g. airports, refineries, etc.) is the same as in Option 2.

Across the industries, the regulatory costs are:

- *Licensing-related costs*: All ongoing users of PFOS (other than fire fighting) would incur licensing costs of $815 per business comprising monitoring and reporting to satisfy the licence requirements. The total cost across all businesses is estimated to average $28,351 per year noting that the number of businesses incurring this cost declines year on year due to businesses transitioning away from PFOS use.
- *Cost of alternatives*: The transition cost to non-PFOS alternatives associated with product trials, system changes, cost of alternatives, and destruction of old stock is estimated at $1,146,587 per annum. This is more than Option 2 which only includes the cost of alternatives in fire fighting. Option 3 assumes transition costs for all industries that use PFOS other than x-ray photography. Transition rates, timing and costs vary by industry.
- *Waste management (hard chromium plating)*: Ongoing costs for process improvement and waste management for businesses continuing to use PFOS in the hard chromium plating industry are estimated at $134,544 per annum. This is less than Option 2 as there is assumed to be increased transition to alternatives under Option 3.
- *Waste management (fire fighting)*: Site clean-up and waste disposal costs for waste water where PFOS containing foams continue to be used in fire fighting are estimated at $9,557,501 per annum. This is the same as for Option 2.
- *Waste management (biosolids released from waste infrastructure):* Industry costs for monitoring and appropriate disposal or treatment of PFOS-containing biosolids are $1,021,895 per annum. This is the same as for Option 2.

Option 4 – Ratify and phase out all non-essential uses	**$4,009,307 p.a.**

Under this option Australia would: *(i)* ratify the amendment and register for the acceptable purpose for photo-imaging and certain medical devices only; *(ii)* introduce industry labelling to increase recovery rates of x-rays; *(iii)* ban all other uses, manufacture, import and export of PFOS except for laboratory research and environmentally sound disposal; *(iv)* phase out current uses in hard chromium plating, decorative plating and plastics etching. There would also be a ban on the continued use of stocks of PFOS-containing fire fighting foams. Stockpiles would need to be disposed of in an environmentally sound manner consistent with the Stockholm Convention.

Costs for affected industries under this option include the following compliance and administrative costs. Similar to Options 2 and 3, no delay costs would occur.

Hard chromium plating

Under this option, all hard chromium plating businesses will incur the costs of transitioning away from PFOS use as described in Option 3.

For the businesses that transition away from PFOS containing products, three establishment costs are identified:

- non-PFOS system establishment costs spread across years 2 to 5 ($2,090 per business comprising capital expenditure on equipment)
- transition costs spread across years 2 to 5 ($2,090 per business comprising operational expenditure to update management practices and technical knowledge)
- non-PFOS product trial ($13,064 total for the hard chromium plating industry, representing half of a cost shared with government).

There is also an ongoing cost for non-PFOS alternatives ($10,346 per business per year).

Businesses that have not yet transitioned will incur licensing costs of $815 per business per year comprising monitoring and reporting.

Decorative chromium plating

The costs are the same as in Option 3.

Plastics etching

The costs are the same as in Option 3.

Photography

Under this option, ongoing costs are identified for labelling and recycling (a total of $65,319 per annum in for each year from year 2 onwards) as well as licensing-related monitoring and reporting costs ($815 per business).

Fire fighting

Under this option, regulatory burden costs to industry are significantly reduced as site clean-up costs and waste management costs are limited to a small number of sites where fire fighting foams continue to be used for a short period following ratification. The most significant costs identified relate to destruction of fire fighting foams. It is assumed that businesses will take all remaining stocks out of circulation and destroy them within three years rather than storing them.

Across the industries, the regulatory costs are:

- *Licensing-related costs*: The licensing costs for monitoring and reporting to satisfy the licence requirements would be incurred by all users of PFOS (other than fire fighting) and are estimated at $20,026 per annum. This is slightly less than for Option 3 and is driven by the assumption that it takes five years for all chromium plating users to complete the transition to non-PFOS alternatives. A more realistic timeframe for accelerated phase out will be tested during the consultation.

- *Cost of alternatives*: The transition cost to non-PFOS alternatives for product trials, system changes, cost of alternatives, and destruction of old stock is estimated at $2,522,291 per annum. This is significantly higher than Options 2 and 3 and is mostly due to increased destruction and replacement costs incurred by the fire fighting industry for existing fire fighting foam stocks.
- *Waste management (photography industry)*: A labelling and recycling program for the photography industry to manage PFOS is estimated to cost $58,787 per annum. This is a new cost for this option.
- *Waste management (hard chromium plating)*: There are no costs for improved waste management in hard chromium plating for this option as it is assumed that all businesses transition to alternatives.
- *Waste management (fire fighting)*: Site clean-up and waste disposal costs for waste water where PFOS containing foams continue to be used in fire fighting in the first two years only are estimated at $386,308 per annum over a ten year period.
- *Waste management (biosolids released from waste infrastructure):* Industry costs for the monitoring of biosolids and appropriate disposal or treatment of PFOS-containing biosolids are $1,021,895. This is the same as for Options 2 and 3.

Summary of RBM for Options 2 to 4

Option 2

Industry\Costs	Costs related to import certification	Cost of alternatives	Waste management	**Total**
- Hard Chromium Plating	16,719		222,924	239,643
- Decorative Chromium Plating	97,821			97,821
- Plastics etching	815			815
- Photography	1,630			1,630
- fire fighting foam	22,114	955,335	9,557,501	10,534,950
- Water			1,021,895	1,021,895
Total	139,100	955,335	10,802,320	**11,896,756**

Option 3

Industry\Costs	Costs related to licensing	Cost of alternatives	Waste management	**Total**
- Hard Chromium Plating	10,091	102,366	134,544	247,001
- Decorative Chromium Plating	16,630	51,471		68,101

- Plastics etching		37,415		37,415
- Photography	1,630			1,630
- fire fighting foam		955,335	9,557,501	10,512,836
- Water			1,021,895	1,021,895
Total	28,351	1,146,587	10,713,940	**11,888,878**

Option 4

Industry\Costs	Costs related to licensing	Cost of alternatives	Waste management	**Total**
- Hard Chromium Plating	2,581	201,774		204,355
- Decorative Chromium Plating	16,630	51,471		68,101
- Plastics etching		37,415		37,415
- Photography	815		58,787	59,602
- fire fighting foam		2,231,632	386,308	2,617,940
- Water			1,021,895	1,021,895
Total	20,026	2,522,291	1,466,990	**4,009,307**

Attachment D

List of reports

The following reports were commissioned by the Department of the Environment and Energy to assist with developing the options and analysis for the decision on ratification of the listing of PFOS on the Stockholm Convention and implementation options for managing PFOS.

These reports are available at: http://www.environment.gov.au/protection/chemicals-management/pfas.

The Development of Methodolog(ies) for Identification and Segregation of Articles Containing Hazardous Chemicals (PBDEs and PFOS), Australian Environment Agency, 26 May 2011

PFOS Industry Profiling and CBA Consultancy: Part 1 – Industry Profiling Report, Infotech Research, 14 December 2012

PFOS Industry Profiling and CBA Consultancy: Part 2 – Implementation Options Report, Infotech Research, 14 December 2012

PFOS Industry Profiling and CBA Consultancy: Technical Advice on the Use, Management, Disposal and Treatment of PFOS and PFOS Containing Wastes – Effectiveness of PFOS Alternatives Report, Infotech Research, 14 December 2012

PFOS Industry Profiling and CBA Consultancy: Technical Advice on the Use, Management, Disposal and Treatment of PFOS and PFOS Containing Wastes – PFOS Disposal Methods and Services Report, Infotech Research, 14 December 2012

PFOS Control Measures: Cost Benefit Analysis, Essential Economics, February 2013

PFOS Industry Profiling and CBA Consultancy: Executive Summary Report, Infotech Research, 19 February 2013

Update of 2011 and 2012 Analytical Information for PFOS: Final Report, Infotech Research, 11 September 2014

Cost benefit analyses relating to the ratification of the amendments to list four chemicals on the Stockholm Convention: Cost benefit analysis report – Final report, Marsden Jacob Associates, September 2015

Attachment E

Supplementary analysis by the Department of the Environment and Energy

The summary costings presented in this RIS for the cost benefit analysis and regulatory burden measurement are based on the detailed costings and assumptions presented in this Attachment. It relies on supporting analysis commissioned by the Department including:

- An initial cost benefit analysis undertaken by Essential Economics (2013). This report uses the regulatory options and cost assumptions developed by Infotech (2012a, 2012b, 2012c etc.).
- An updated cost benefit analysis by Marsden Jacobs Associates (2015). This work broadly used the same cost assumptions as the 2013 CBA but updates the costs from 2012-13 to 2014-15 dollar values. The PFOS consumption models were also updated to include revised information on use (Infotech, 2014).

The Department has amended the costings presented in preceding CBAs by developing a new base case, updating some assumptions and deferring the start date of the costings model (from 2017-18 to 2015 16) to reflect a more realistic implementation date.

Further information on the derivation of the detailed costings presented in this Attachment is available in the supporting analysis and reports, available for information at www.

Base case outline

A new option has been added to the three scenarios used in the previous CBAs. The new option represents the true status quo with no new policy intervention and is used as the base case (i.e. Option 1). Key assumptions include:

- Consumption of PFOS for each industry continues current trends, and is the same as for Option 2 (see Table F1).
- Emissions are calculated from the annual consumption and environmental fate for each industry which are not corrected for improvements to waste management practices for fire fighting foam (see Figure 8).
- fire fighting foam stocks removed from use are assumed to be emitted into the environment from disposal operations that do not involve destruction of the PFOS content. Therefore, there are not costs attributed to destruction of fire fighting foam stocks.
- There are no costs attributed to business choices to transition to alternatives.

General assumptions and limitations of the model

It should be noted that the CBA does not include Option 1. At the time it was not considered a feasible option for there to be no new policy intervention due to uncertainty to importing businesses. While Option 1 is still not considered a feasible option, the Department subsequently added this as the reference scenario representing the true status quo.

The figures in the CBA have been updated in this impact analysis. For the impact analysis the Department has recalculated the results of the CBA to account for the new base case. Further, the Department revised the start date for the CBA modelled period from 2015-16 to 2017-18 to reflect a more realistic implementation date. The cost assumptions and calculations used are based on those in the Marsden Jacob Associates CBA. These are provided in the tables below and are annotated with any updates made by the Department.

The results of the cost benefit analysis (CBA) are presented using the present value (PV) of costs incurred.

Where possible the costs have been quantified in dollar terms, however there are limitations in the results due to the number of assumptions.

The calculations are informed by a material flows analysis which estimated the quantities of PFOS that would be used, disposed of and reach the environment under each option. Key trends in use and consumption are described under each scenario. Modelled consumption and emissions for each option are included at *Attachment F*. Emissions to the environment have been determined by applying the estimated fate of PFOS in the environment to the amount of PFOS consumed for each use. These estimates were adjusted as required for each option that included controls that would prevent or divert releases to the environment as follows:

- Controls on use of PFOS in fire fighting and requirements for appropriate destruction of wastes in Options 2 and 3 are assumed to reduce the amount of consumed PFOS entering waterways to 5% (compared to 65% for Option 1) with no other releases to the environment (apart from accidental releases in the first two years before controls are in place).

- Effects of controls on uses other than fire fighting foam have not been modelled in the material flows, therefore benefits may be underestimated (although this is small due to the comparatively large contribution of fire fighting foam.

There are assumptions that are relevant to multiple options, for example the cost of PFOS destruction (on a weight basis). These assumptions were combined with the quantities of PFOS in the material flow analysis to estimate the total costs. Further information on assumptions for costs is available in *Attachment E*.

The costs and benefits for each option were calculated over a 20 year period (2017-18 to 2036-37). The regulatory burden measurement was determined over the first 10 years of the period. The values are in 2014-15 dollars but in many instances have been updated from 2012-13 estimates. A discount rate of 7 per cent was used. Sensitivity analysis of key variables appears as the end of this impacts section.

Due to the persistent nature of PFOS a significantly longer time period could have been used to calculate the net present values.

The distribution of costs across governments has not been calculated and would depend on the implementation approach.

Not all impacts of PFOS are easily quantifiable. For example, impacts to the environment and potential impacts to human health could not be costed. It is important to consider all impacts, not just those for which economic costs could be assigned, when reviewing the net present values and determining the preferred option.

Importantly given the relative contribution of fire fighting foam management to the costs, it is assumed under the base case that businesses using PFOS-containing fire fighting foam will have already implemented adequate drainage control measures. The criteria for adequacy are set out in existing nationally consistent published standards, such as the Australian Standards relevant to fire safety and protection. The percentage of capture of firewater that is assumed under Options 2, 3 and 4 would require significant additional expenditure for a major hazard site without impermeable bunding already in place.

CBA cost assumptions

The following tables contain complete listings of cost assumptions applied to government and industries under the base case and alternative scenarios for PFOS. These costs are also used in the regulatory burden measurement. All costs have been drawn from cost assumptions applied in previous PFOS CBAs (Essential Economics, 2013; Marsden Jacob Associates, 2015) and are provided in $2014-15 values.

Table E1 – Government Costs Details

Activity		Cost	Value	Comment
Option 2				
Certification	Certification	One off set up costs for certification	$26,650	
		Annual certification costs, year 1 onwards	$209,000/yr	
		Annual costs for licensing and monitoring where PFOS used in metal plating	$12,541/yr	
	Reporting	One off costs for reporting system associated with certification	$78,382	
		Annual reporting costs	$12,541/yr	
	Education	One off costs for industry education/training in year 1.	$39,191	This cost is the same for Options 2 and 3
		Ongoing training costs for industry, years 1-20	$6,270/yr	The annual cost is the same for Options 2, 3 and 4
Waste Infrastructure	Landfill monitoring	Landfill leachate sampling cost, years 1-5	$60,198/yr	This cost is the same for Options 2, 3 and 4
		Landfill leachate analysis cost, years 1-5	$50,165/yr	
Option 3				
Licensing and Regulation	Transition to alternatives	One off non-PFOS product trial	$13,063	This cost is the same for Options 3 and 4. The cost is shared with industry.
	PFOS licensing	Monitoring and enforcement associated with introduction of alternatives and destruction of PFOS-containing firewater, year 1 onwards	$177,144/yr	
	Site Cleanup Supervision	Site cleanup supervision where PFOS based fire fighting foams used	$39,191	
		Site cleanup supervision where PFOS based fire fighting foams used, years 1-5	$12,541/yr	
	Import Control	Registration costs for PFOS	$78,382	This cost is the same for Options 3 and 4
		Administrative oversight of PFOS importation	$12,541/yr	This cost is the same for Options 3 and 4
	Reporting	One off costs for reporting system associated with ratification	$65,318	
		Annual reporting costs, year 1 onwards	$26,127/yr	
	Education	One off costs for industry education/training in year 1.	$39,191	This cost is the same for Options 2 and 3
		Annual training costs for industry, years 1-5	$6,270/yr	The annual cost is the same for Options 2, 3 and 4.
Waste Infrastructure	Landfill monitoring	Landfill leachate sampling cost, years 1-5	$60,198/yr	This cost is the same for Options 2, 3 and 4
		Landfill leachate analysis cost, years 1-5	$50,165/yr	

Option 4				
Licensing and registration	Transition to alternatives	One off non-PFOS product trial	$13,063	This cost is the same for Options 3 and 4. The cost is shared with industry.
		Industry assistance, years 1-3	$195,956/yr	
		Industry assistance, years 4-5	$65,318/yr	
	PFOS licensing	Site cleanup supervision where PFOS based fire fighting foams used	$78,382	This cost is the same for Options 3 and 4
		Monitoring and enforcement of PFOS associated with permitted use	$39,191/yr	
		Monitoring and enforcement of PFOS associated with ban	$179,652/yr	
	Import Control	Registration costs for PFOS	$78,382	This cost is the same for Options 3 and 4
		Administrative oversight of PFOS importation	$12,541/yr	This cost is the same for Options 3 and 4
	Reporting	Annual reporting costs, year 1 onwards	$26,127/yr	This cost is the same for options 3 and 4
	Education	One off costs for industry education/training in year 1.	$78,382	This cost is higher than for Option 2 and 3
		Annual training costs for industry, years 1-20	$6,270/yr	The annual cost is the same for Options 2, 3 and 4.
Waste Infrastructure	Landfill monitoring	Landfill leachate sampling cost, years 1-5	$60,198/yr	This cost is the same for Options 2, 3 and 4
		Landfill leachate analysis cost, years 1-5	$50,165/yr	

Table E2 – Industry Costs Details – Hard Chromium Plating

Parameter	Option	Value	Assumption, comment and calculation
Starting number of businesses (A_i)	All	22	The Marsden Jacob Associates CBA assumed 25 starting businesses for the period commencing 2015–16. The base case estimate for number of businesses in 2016-17 was used as the starting number of businesses for the 20 year period commencing 2017–18.
Number of businesses still using PFOS (A)	1 and 2	Reduces to 18 by year 20	Declines at same rate of PFOS consumption for this use
	3	Reduces to 10 by year 5, further reduces to 9 by year 20	50% of businesses transition to a non-PFOS alternative following ratification with registration of acceptable purpose (closed-loop) and specific exemption (open-loop) within 5 years. Number of businesses declines in line with consumption. Business numbers decline at same rate of PFOS consumption thereafter.
	4	Reduces to 0 by year 6	100% transition to non-PFOS alternatives following ratification with no registration
Import certification – staff time (B_c)	2	$815/business/yr	Applies only to businesses that still use PFOS Total annual cost calculated as A x B_c
Licensing use (B_l)	3 and 4	$815/business/yr	Applies only to businesses that still use PFOS Total annual cost calculated as A x B_l
Process improvement (C)	2 and 3	$209/business/yr	Applies only to businesses that still use PFOS Total annual cost calculated as (A_i-A) x C
Waste management (D)	2, 3 and 4	$10,659/business/yr	Annual cost calculated as D x A. Assumes 1 tonne of sludge produced per business each year, and destruction and transport costs of $10,000 and $200, respectively, per tonne of sludge
Cost of non-PFOS alternative (E)	3 and 4	$10,346/business/yr	Applies only to businesses that cease PFOS use Total annual cost calculated as (A_i-A) x E
Non-PFOS system establishment costs (F)	3 and 4	$2,090/business	Applies only to businesses that cease PFOS use. One off cost calculated as (A_i-A) x F
Transition costs (G)	3 and 4	$2,090/business	Applies only to businesses that cease PFOS use Total annual cost calculated as (A_i-A) x G
Non-PFOS Product Trial	3 and 4	$13,064	One off cost

Table E3 – Industry Costs Details – Decorative Chromium Plating

Parameter	Option	Value	Assumption
Starting number of businesses (A_i)	All	120	The Marsden Jacob Associates CBA assumed 150 starting businesses for the model commencing 2015–16. The base case estimate for number of businesses in 2016-17 was used as the starting number of businesses for the 20 year period commencing 2017–18.
Number of businesses still using PFOS (A)	1 and 2	Remains at 120 over the 20 year period	Declines at same rate of PFOS consumption for this use
	3 and 4	Reduces to 0 by year 5	100% transition to non-PFOS alternatives within 5 years of ratification
Import certification – staff time (B_c)	2	$815/business/yr	Applies only to businesses that still use PFOS Total annual cost calculated as A x B_c
Licensing use (B_l)	3 and 4	$815/business/yr	Applies only to businesses that still use PFOS Total annual cost calculated as A x B_l
Non-PFOS system establishment costs (C)	3 and 4	$2,090/business	Applies only to businesses that have ceased PFOS use Total annual cost calculated as (A_i-A) x C
Transition costs (D)	3 and 4	$2,090/business	Applies to all businesses as they cease PFOS use. One off cost calculated as A_i x D
Non-PFOS product trial	3 and 4	$13,064	One off cost

Table E4 – Industry Costs Details – Plastics Etching

Parameter	Option	Value	Assumption
Starting number of businesses (A_i)	All	1	
Number of businesses using PFOS (A)	1 and 2	1	No change over time
	3 and 4	Reduces to 0 in year 1	
Import certification – staff time (B_c)	2	$815/business/yr	Applies only to businesses that still use PFOS Total annual cost calculated as A x B_c
Cost of non-PFOS alternative (C)	3	$40,759/business/yr	Total annual cost calculated as (A_i-A) x C
One off cost of establishing a non-PFOS system (D)	3 and 4	$5,225/business	One off cost
Transition costs (E)	3 and 4	$2,090/business	Total annual cost calculated as (A_i-A) x E

Table E5 – Industry Costs Details – X-ray photography

Parameter	Option	Value	Assumption
Number of businesses that use PFOS (A)	All	2	No change over time
Cost of import certification for X-ray (B_c)	2	$815/business/yr	Total annual cost calculated as A x B_c
Licensing of PFOS use in X-ray (B_l)	3 and 4	$815/business/yr	Total annual cost calculated as A x B_l
Labelling and recycling program for PFOS destruction in X-ray (D)	4	$65,319/yr	Annual cost

Table E6 – Industry Costs Details – Fire fighting

Parameter	Option	Value	Assumption
Starting number of facilities with PFOS (A_i)	All	46	The Marsden Jacob Associates CBA assumed 50 facilities with PFOS for the model commencing 2015–16. The base case estimate for number of facilities in 2016-17 was used as the starting number for the 20 year period commencing 2017–18.
Number of remaining facilities with PFOS (A)	1, 2 and 3	Reduces to 1 by year 20	Declines at same rate of PFOS consumption for this use
	4	Reduces to 0 by year 3	100% transition to non-PFOS alternatives following ban on use
Import certification (B_c)	2	$815/business/yr	50 facilities, declining over time. Total annual cost calculated as A x B_c.
Site cleanup (C)	2 and 3	$830,853/site	Assumes 3-4 sites/yr and clean-up in the same year use ceases. Total annual cost calculated as (A_{year-1}-A_{year}) x C.
	4	$830,853/site	Assumes 2 sites/yr in years 1 and 2 only following immediate phase out of PFOS use
Waste management – disposal of firewaters(D)	2, 3 and 4	$6,542/kg PFOS	The previous CBA (Essential Economics, 2013) quoted these costs as $10,200/kg. However, initial source (Infotech Research, 2012) calculates costs as $6,260/kg ($6,542 when inflated to 2014/15). Initial source is used. Total annual cost calculated as D x kg consumed.
Destruction of fire fighting foam stocks (E)	2, 3 and 4	$448/kg PFOS	Total annual cost calculated as E x kg of PFOS consumed
Replacement of PFOS-containing fire fighting foam (F)	2, 3 and 4	$418/kg PFOS	Total annual cost calculated as F x kg consumed

Table E7 – Industry Costs Details – Water Utilities[135]

Parameter	Option	Value	Assumption
Sewage treatment plant biosolids sampling costs	2, 3 and 4	$55,181/yr	Annual cost in years 1-5
Sewage treatment plant biosolids analysis costs	2, 3 and 4	$83,608/yr	Annual cost in years 1-5
Biosolids landfilled	2, 3 and 4	0 to 150,282 tonnes/year	Increases by 1.2% per year
Biosolids – landfilling costs	2, 3 and 4	$157/dry tonne – central $70/dry tonne – best $240/dry tonne – worst	Total cost based on central case, total kg and probabilities estimates[136]
Biosolids applied to land	2, 3 and 4	0 to 183,678 tonnes/year	Increases by 1.2% per year
Biosolids value when applied to land	2, 3 and 4	$40/dry tonne	Total value based on total kg and probabilities estimates
Biosolids treatment – planning and regulatory approval one off costs	2, 3 and 4	$1,045,098	One off cost. Total value adjusts for probability estimate
Biosolids treatment – stakeholder engagement one off costs	2, 3 and 4	$783,824	One off cost. Total value adjusts for probability estimate
Biosolids treatment – hazardous waste incineration	2, 3 and 4	$1,017/dry tonne	Total cost based on total kg and probabilities estimates
Biosolids treatment – base catalysed decomposition	2, 3 and 4	$766/dry tonne	Total cost based on total kg and probabilities estimates
Biosolids treatment – plasma arc	2, 3 and 4	$1,649/dry tonne	Total cost based on total kg and probabilities estimates
Biosolids treatment – hazardous waste incineration – operating cost	2, 3 and 4	$476/dry tonne	Total cost based on total kg and probabilities estimates
Biosolids treatment – base catalysed decomposition – operating cost	2, 3 and 4	$2,881/dry tonne	Total cost based on total kg and probabilities estimates
Biosolids treatment – plasma arc – operating cost	2, 3 and 4	$3,085/dry tonne	Total cost based on total kg and probabilities estimates

[135] The previous CBA (Essential Economics, 2013) did not include these costs. Costs used in this analysis are based on detailed estimates provided in ACIL Tasman & KMH, 2013.
[136] Refer to Figure C7 in *Attachment C* for information on probabilities for biosolids outcomes.

Table E8 - Landfill monitoring cost details[137]

Data variable	Assumed value	Unit
Sampling frequency (samplings per site per annum)	4	#
Number of landfills	122	#
Sampling rate	10.0%	%
Number of sampling sites across Australia	12	#
Number of samples per site per occasion	2	#
Time taken for sampling each site on each occasion (hours)	4	hours
Cost of analysing each sample	523	$
Labour cost of sampling (per hour)	157	$
Hours per month for reporting sampling results	16	hours
Labour cost of results reporting (per hour)	157	$

Table E9 - Sewage Treatment Plant (STP) monitoring cost details[138]

Data variable	Assumed value	Unit
Sampling frequency (samplings per site per annum)	4	#
Number of STPs	93	#
Sampling rate	10.0%	%
Number of sampling sites across Australia	10	#
Number of samples per site per occasion (influent and effluent samples)	4	#
Time taken for sampling each site on each occasion	4	hours
Cost of analysing each sample	500	$
Labour cost of sampling (per hour)	150	$
Hours per month for reporting sampling results	16	hours
Labour cost of results reporting (per hour)	150	$

137 Source: ACIL Tasman & KMH 2013
138 Source: ACIL Tasman & KMH 2013

Attachment F

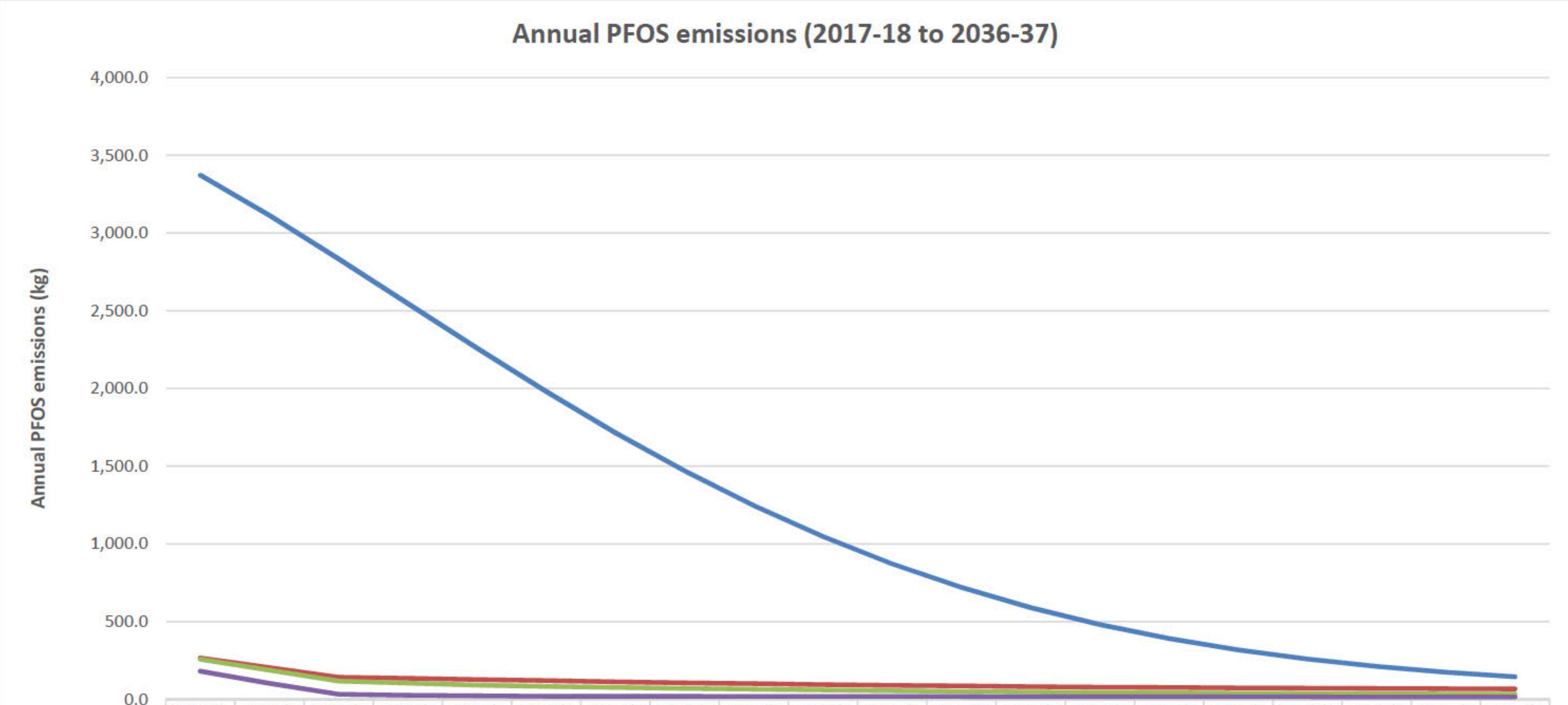
Projected PFOS consumption and emissions

Table F1: Estimated annual PFOS consumption (kg) by use over the modelled period (2017-18 to 2036-37)

Use	Option	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
Hard chromium plating use	1 and 2	129	127	126	125	124	122	121	120	119	118	116	115	114	113	112	111	110	108	107	106
	3	116	102	88	75	62	61	61	60	59	59	58	58	57	56	56	55	55	54	54	53
	4	100	50	25	10	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decorative chromium plating & plastics etching	1 and 2	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	3 and 4	15	10	5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fire fighting foam used from legacy stocks	1, 2 and 3	1,745	1,608	1,460	1,308	1,157	1,009	869	740	622	516	424	344	275	218	171	133	102	77	58	43
	4	130	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fire fighting foam destroyed from legacy stocks[139]	1, 2 and 3	1,745	1,608	1,460	1,308	1,157	1,009	869	740	622	516	424	344	275	218	171	133	102	77	58	43
	4	12,856	6,428	6,493	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Photography	1, 2, 3 and 4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Photography stocks disposed[140]	1, 2, 3 and 4	122	119	117	114	112	110	108	106	103	101	99	97	95	93	92	90	88	86	84	83

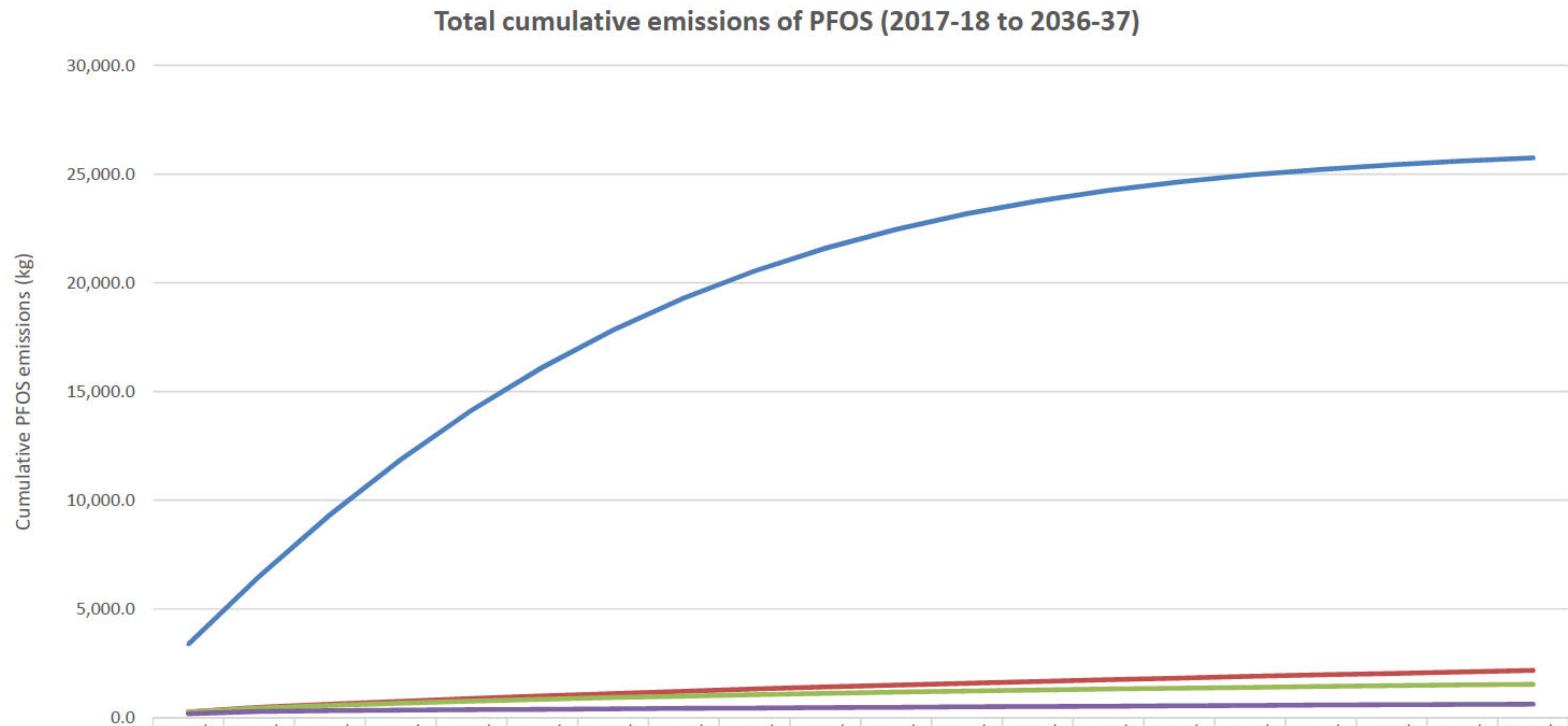
Figure F1. Annual emissions of PFOS (2017-18 to 2036-37)

139 This is not a direct use but affects how much fire fighting foam is available for use from the assumed existing stockpile (25,971 kilograms at the start of 2017-18)
140 This is not a direct use but is the volume of PFOS estimated in photographic materials sent to landfill as this is more significant in determining annual emissions.



	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36	2036/37
Base case	3,373.1	3,113.3	2,834.1	2,546.2	2,258.8	1,979.8	1,715.2	1,469.7	1,246.2	1,046.5	871.0	719.1	589.8	481.2	391.4	318.0	258.8	211.7	174.6	145.8
Option 2	266.1	204.4	142.3	134.7	127.2	119.8	112.8	106.3	100.3	94.9	90.1	85.8	82.0	78.8	76.0	73.6	71.6	69.8	68.3	67.0
Option 3	257.8	188.0	117.8	104.7	91.8	83.8	77.0	70.7	64.9	59.7	55.0	50.9	47.3	44.3	41.7	39.5	37.6	36.0	34.7	33.5
Option 4	181.1	103.1	32.9	26.1	22.4	19.6	19.2	18.8	18.5	18.1	17.7	17.4	17.0	16.7	16.4	16.0	15.7	15.4	15.1	14.8

Figure F2. Total cumulative emissions of PFOS (2017-18 to 2036-37)



	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36	2036/37
Base case	3,373.1	6,486.4	9,320.5	11,866.	14,125.	16,105.	17,820.	19,290.	20,536.	21,582.	22,453.	23,173.	23,762.	24,244.	24,635.	24,953.	25,212.	25,423.	25,598.	25,744.
Option 2	266.1	470.5	612.7	747.4	874.6	994.4	1,107.3	1,213.6	1,313.9	1,408.8	1,498.9	1,584.7	1,666.7	1,745.5	1,821.6	1,895.2	1,966.8	2,036.6	2,104.9	2,171.9
Option 3	257.8	445.8	563.6	668.4	760.2	844.0	921.0	991.7	1,056.6	1,116.2	1,171.2	1,222.1	1,269.5	1,313.8	1,355.5	1,394.9	1,432.5	1,468.5	1,503.2	1,536.8
Option 4	181.1	284.2	317.1	343.2	365.6	385.3	404.5	423.3	441.8	459.9	477.6	495.0	512.0	528.7	545.1	561.1	576.8	592.2	607.3	622.1

Attachment G

Profiles for industries currently using PFOS

The following profiles of industries currently using PFOS in Australia draw on independent research conducted for the Department of the Environment and Energy.

The discussion of business size distribution in each industry using PFOS applies the following categories: small business (around 1-19 employees), medium business (around 20-199 employees) and large business (around 200 or more employees). However, especially in large businesses, there may only be a division or unit of the business involved in the activity using PFOS.

The discussion also refers to closed-loop systems as a core element of the sound management of PFOS. Although there is no formal definition of a closed-loop system, the essential requirement for the purposes of this RIS is that there are hardly any emissions of PFOS throughout the chemical life cycle i.e. the entire production, use and waste disposal process.[141] The section *What does sound management look like?* provides more information.

7.4.1.1 Hard chromium plating

In metal plating, the object to be plated is dipped into a plating bath filled with plating liquid. There are two metal plating processes using PFOS: hard chromium plating and decorative chromium plating, which is discussed in the following section. The hard chromium plating process is also known as engineering chrome plating, functional chrome plating or hard metal plating.

In 2014 it was estimated that 25 hard chromium plating businesses were operating in Australia. Around half were small businesses, a third were medium size businesses and the remainder large businesses. Customers for hard chromium plating included original equipment manufacturers (OEM) and equipment repair services, mainly in the mining industry. The distribution across jurisdictions was broadly in line with the population, except for higher demand in Queensland and Western Australia due to the mining industry.

The hard chromium plating process uses a plating bath to apply a thick protective layer of chromium to metal objects for use in heavy engineering applications. When used in mist suppressants, PFOS forms a film over the surface of the plating bath protecting workers from the highly toxic hexavalent chromium (chromium VI) mist. The mist suppressant system is a key safety and health management function for hard chromium plating facilities due to the classification of hexavalent chromium as a carcinogen by the International Agency for Research on Cancer.[142]

The hard chromium plating industry has a high demand for mist suppressant, reflecting the longer time taken and the higher electrical currents used, compared to decorative chromium plating. The level of PFOS salts in these mist suppressants is estimated at 4-5% PFOS, leading to around 0.1 to 0.2 g PFOS per litre of plating solution. Although electrolysis during the plating process may destroy some PFOS, the presence of high levels of PFOS in plating waste is a concern for the hard chromium plating businesses that continue to use PFOS.

[141] See UNEP (2016).
[142] See IARC (2011)

The Australian suppliers of mist suppressant in 2014 included two businesses offering PFOS-containing products and one business offering only PFOS-free products. Hard chromium plating businesses were also purchasing products from overseas, including a PFOS-containing product from China. Since this time, changes in the industry may have altered the availability and composition of PFOS-containing mist suppressant for hard chromium plating businesses in Australia. Advice from industry is that hard chromium plating businesses typically store around six to 12 months of mist suppressant stocks while suppliers keep around 3 months of stocks.

The use of water is a possible source of PFOS emissions for hard chromium plating businesses. As objects are removed from the plating bath, they are sprayed with water and may be rinsed. The spray and rinse water and any PFOS contained in this water are typically returned to the plating bath. Research suggests that most hard chromium plating businesses in Australia are already recycling water into the plating bath and are not connected to the municipal sewerage system.

The other possible source of PFOS emissions in hard chromium plating is from the disposal of plating sludge. Most of the PFOS added to plating baths eventually partitions out into sludge and collects on the surfaces of the plating tank and extraction system ducts where it is typically periodically removed for disposal. Sludge is also removed through a range of plating bath purification methods. Most states already have requirements for the treatment and/or disposal of sludge to manage its hazardous hexavalent chromium content, typically disposal to secure hazardous waste landfill. However, there is thought to be currently no requirement for the disposal process to take into account the presence of PFOS in the sludge.

Depending on the way in which rinse water and plating sludge are managed and disposed of, it is possible for hard chromium plating businesses using PFOS to operate as a closed-loop system. A transition to using trivalent chromium rather than the toxic hexavalent chromium is not considered feasible for hard chromium plating due to recognised quality problems with the resulting product.

Mechanical mist extraction systems are available used in conjunction with gas scrubbers. These are expensive, produce a high volume of chromium waste and may not be able to recover PFOS if a PFOS-containing mist suppressant is used in conjunction with the mist extraction system. Another option is a mechanical mist barrier, comprising a solid surface that reduces airflow to condense mist droplets. These include floating balls, screen and mesh systems, hoods and barrels.

As well as mechanical systems, hard chromium plating businesses seeking to reduce or eliminate the use of PFOS can replace PFOS mist suppressants with PFOS alternatives. As at 2014, one of the businesses supplying mist suppressant to the hard chromium plating industry estimated that around 90% of the Australian market was for non-PFOS products.

Despite the widespread uptake of PFOS alternatives, there is a perception among some hard chromium plating businesses that the PFOS alternative mist suppressants are not equivalent to PFOS mist suppressants. The research does not support negative perceptions about the performance of PFOS alternatives, although there may be visual differences in characteristics such as viscosity and foaming. In terms of cost, suppliers report that PFOS alternatives have a cost per unit of production that is similar to PFOS products. However, some hard chromium plating businesses have reported that in practice the cost is higher, based on a higher cost per kilogram and a higher consumption rate.

7.4.1.2 Decorative chromium plating including plastics etching

The preceding section on Hard chromium plating provides information relevant to decorative chromium plating, including mist suppressant suppliers.

The decorative chromium plating process applies a surface finish layer on manufactured parts ranging from plastics to steel. Some of the businesses offering decorative chromium plating also offer etching of plastics prior to plating.

In 2014 it was estimated that 150 decorative chromium plating businesses were operating in Australia, with three of these businesses also offering plastics etching. Around 83% were small businesses, 10% were medium businesses and 7% were large businesses. The distribution of the industry broadly reflected population except for higher activity in Victoria and lower activity in Western Australia. The customer base for decorative chromium plating spans the auto, consumer durables, interior design and furniture and construction industries along with ad-hoc repairs, maintenance and refurbishment of goods. The closure of the auto industry was predicted to reduce the decorative chromium plating industry in South Australia and Victoria.

Traditional methods of decorative chromium plating and plastics etching use chromium (VI) and therefore require a mist suppressant. The performance requirements are not as onerous compared to hard chromium plating, however, due to much lower electrolysis times. PFOS can also be used in plastics etching as a wetting agent and mist suppressant.

Most decorative chromium platers have already transitioned away from using PFOS based mist suppressant as PFOS alternatives became available on the market. Alternate plating systems are also available using chromium (III).

7.4.1.3 Photography

PFOS is imported into Australia for use in X-ray photography. It may also be imported for use in CCD units in some older video endoscopes.

When used in photographic materials, such as X-ray film, PFOS helps in controlling electrostatic charge, friction and adhesion and repels dirt.

Another historical use of PFOS that may continue is in older medical imaging devices. Globally it is estimated that 70 per cent of video endoscopes still contain a charged-coupled device (CCD) colour filter with a small amount (150 ng) of PFOS. It is unknown how many of these older machines are still used in Australia. When the CCD colour filter fails, standard practice was for the manufacturer to replace it with another CCD of the same type until the video endoscope reached the end of its useful life.

Use of PFOS in medical imaging is declining with the increased use of replacement technology such as digital imaging. Although this overall trend is expected to continue, there are no known alternatives for the use of PFOS in X-ray photography. The Stockholm Convention recognises that medical uses in X-ray films are an essential use of PFOS.

The use of PFOS-containing CCDs in video endoscopes is being phased out as older devices are decommissioned. Newer devices are PFOS-free.

X-ray films are disposed of after use and most of the PFOS used in X-ray photography remains associated with the developed film. About 40 to 50 per cent of X-ray films are recovered from waste streams and recycled to recover silver. This process involves incineration at over 900°C for up to 24 hours, which is considered highly likely to destroy the PFOS component, although its efficacy is unconfirmed.

7.4.1.4 Fire fighting

As at 2013, industry reported holding significant PFOS-containing fire fighting foam stocks at major hazard facilities such as airport hangars, docks. petrochemical facilities and dangerous goods storage facilities. fire fighting foam is also widely used in mining, particularly for fixed fire fighting systems on large mining vehicles. Because of this pattern of use, the vast majority of organisations using PFOS for fire fighting are thought to be large businesses or government organisations.

The risk of accidental emissions is a major driver of the push by state and territory governments and the fire protection industry to shift businesses away from the use of PFOS-containing foams. If releases of PFOS-containing foams occur in a facility with bunding, the discharge can usually be cleaned up. A major release of PFOS to the wider environment can occur, however, if the accident happens in a facility without bunding, or if the foam is exposed to wind, rain, or floodwaters. The recommended approach, supported by the fire protection industry, is a ban on PFOS-containing fire fighting foam and the destruction of all remaining stocks using high temperature incineration.[143]

Historically, the majority of day-to-day use of Class B foam, including fluorinated foam, in the past was for testing and training purposes. The foam industry has developed guidance for minimising or eliminating such use.[144] The Department of Defence, Airservices Australia, state and territory emergency services and some corporate users have moved away from the use of foams with PFOS as an active ingredient.[145] Although stocks may, in some instances, have been kept for use in an emergency, for research, or for testing emergency equipment, the day-to-day use of these foams is believed to be greatly reduced or eliminated, particularly in training and emergency fire fighting. Advice from state and territory governments and industry suggests that existing stocks may still be used, however, for private sector and possibly volunteer fire fighting.

The patterns of private sector use are therefore an important consideration in assessing the adequacy of existing controls. Major sites have risk management systems in place to prevent and respond to adverse events including environmental pollution. However, there is always a risk of system failure allowing PFOS to escape off site into receiving environments and creating a potential pathway for human exposure.

In Australia it is common for major industry (except mining) and therefore industrial fire fighting activities to be located in coastal areas, reflecting the distribution of the population and

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143 See media release from FPA Australia (2015) Highlighting the Facts on fire fighting foams. Available at https://emarketing-au.s3-ap-southeast-2.amazonaws.com/86772/DxMb_03j0D0WPeBdwzSi_Jh9Zds3l_XvIMKiQdu6zWw/1855307.pdf.

144 Firefighting Foam Coalition (2016) Best practice guidance for use of Class B fire fighting foams. Available at http://www.fffc.org/images/bestpracticeguidance2.pdf

145 See http://www.airservicesaustralia.com/environment/firefightingfoam/use-of-fire-fighting-foam/ and http://www.defence.gov.au/id/pfospfoa/FAQs.asp for information on the transition away from PFOS in Australian Government agencies.

economic activity. Fire fighting also takes place in marine settings by fire and emergency services, the maritime industry, and offshore drilling platforms. This pattern of PFOS use poses particular risks to Australian wetland, river, estuary and marine environments that are highly valued for conservation and recreation. As such, industry (including the fire protection industry) and state and territory governments are taking steps to better manage the risks arising from ongoing PFOS use for fire fighting.

The use of PFOS-containing fire fighting foam by international shipping in Australian waters is an important consideration. Fire fighting activities, including training, on ships are governed by the laws of the country in which the ship is registered and the safety and environmental standards set by the International Maritime Organisation.

The NICNAS surveys of PFOS use indicate there are no new imports of PFOS-containing fire fighting foam to Australia. Advice from industry, emergency services and state and territory governments is that existing stocks of PFOS-containing fire fighting foams are gradually being replaced by alternatives as PFOS-containing products reach their expiry date, are used up or are voluntarily disposed to high temperature destruction. In the absence of regulation, however, the environmental fate of these remaining stocks is uncertain.

With the ongoing decline in the day-to-day use of PFOS-containing foams, emergency and accidental emissions are a key remaining source of PFOS emissions from fire fighting. For example, routine training, emergency drills and the triggering of automatic fire suppression systems – whether due to an emergency or a false alarm - can lead to the widespread release of PFOS-containing foam.

In addition to working with industry on voluntary changes, state and territory governments are also strengthening regulation to control the use, disposal and environmental impacts of fire fighting foams containing PFOS. In July 2016, the Queensland Government announced it would ban the future use of fire fighting foams containing PFOS and PFOA, with the responsibility placed on users to minimise environmental impacts from the use of alternate fire fighting foams. South Australia has also announced policies to control the use of PFOS-containing fire fighting foams. The Government is working closely with state and territory governments on these issues.

State and territory governments are working closely with industry to foster a transition to foams that are suitable for use in the Australian environment. Sites likely to impact on sensitive or high conservation value environments, such as surface and groundwater catchments, wetlands, and coastal and marine areas, are a high priority for transition efforts. The owners and managers of these sites are being encouraged to restrict the day-to-day use of PFOS-containing foam and to transition to alternatives, preferably fluorine-free foams, wherever possible.

Numerous users of PFOS-containing foams have already transitioned to non-PFOS products. Some of these alternative products use other PFASs as a surfactant, while others are fluorine-free. All fire fighting foams are harmful if released directly into the environment, so the-selection of alternative products needs to take account of individual site conditions. This includes the ability to minimise the release of foam and firewater in sensitive environments.

Within the Australian Government, Airservices Australia and the Department of Defence, the main past users of PFOS-containing fire fighting foam, have generally transitioned to non-PFOS products at their sites.

State and territory environmental regulation includes provisions to control the disposal of waste that could harm the environment, such as PFOS-containing foam, firewater and contaminated soils that have resulted from fire fighting. These requirements reflect the broader waste management context in each jurisdiction, including the availability, feasibility and affordability of disposal methods.

State and territory governments are tightening requirements for the disposal of PFOS waste from fire fighting. As part of this, governments are working together to develop a broadly consistent approach to prevent Australia becoming one of the few countries where the supply of PFOS-related products remains legal.

This shift in waste management requirements creates a strong incentive for businesses to review their need to use PFOS, and fluorinated foams more broadly, The onus is on users of fire fighting foams to select products that meet their business needs while satisfying regulatory requirements for waste disposal.

For businesses that choose to continue to use PFOS, and are permitted to do so by regulation, a range of remediation technologies is available to immobilise or remove PFOS and other contaminants from waste. This allows safe destruction of the removed material, with the remainder of the waste decontaminated and therefore suitable for disposal in the general waste stream.

Despite the increasingly stringent regulation of fire fighting waste containing PFOS, the priority in an emergency is always the protection of life and safety. For fire and emergency services, this takes precedence over avoiding the generation of PFOS-containing waste. As a result, businesses that continue to stock PFOS-containing fire fighting foam run a high risk of incurring significant waste disposal and remediation costs in the event of an emergency.

Attachment H

Glossary

Abiotic – physical rather than biological, not relating to a living organism

Accident – an event that happens unexpectedly and unintentionally and may cause damage or injury

Acute – once-off or occurring over a short time period, i.e. minutes to hours

Adverse – harmful or disadvantageous

Annex B – annex to the Stockholm Convention covering chemicals listed for restriction

Article – an object designed and manufactured for a particular purpose, such as a consumer product

Aqueous film forming foam (fire fighting foam) – a fire fighting foam concentrate designed to extinguish hydrocarbon flammable liquid fires

Atmosphere – the gaseous part of the environment

Background concentration - the naturally occurring ambient concentration of a substance in the local area

Benthic – living in or on the seabed or the bottom of a water body

Bioaccumulation – accumulation of a chemical within living things

Bioavailability – the availability of a chemical for uptake into living things

Biogeochemical – relating to the interaction of the biological, geological and chemical parts of the environment

Biomass – biological material from living, or recently living, organisms e.g. wood, waste and crops

Biomagnification – increasing levels of a chemical at higher levels in a food chain

Biosolids – organic material recycled from the sewage treatment process that is treated to be safe for use, usually as fertiliser

Biotic – biological, relating to a living organism

Bund – a retaining wall or embankment designed to hold back the flow of a liquid such as firewater – see also impermeable bunded area

Capital cost – cost for the purchase of land, buildings, construction and equipment for the production of good or services

Carbon cycle – cycle of exchange of carbon in the environment between air, water, soils, geology and living things

Carbon sequestration – capture and storage of carbon dioxide from the atmosphere

Charge-coupled device – a device for capturing digital images

Chemical identity – a name that uniquely identifies a chemical in accordance with the nomenclature systems of the International Union of Pure and Applied Chemistry (IUPAC), the Chemical Abstracts Services (CAS), or a technical name

Chemical substances – chemical elements and their compounds in the natural state or obtained by a production process, but excluding any solvents that can be separated without affecting the stability or composition of the substance

Chromium – a metal used to create corrosion-resistant plating

Chronic – continuous or repeated over an extended time period, i.e. months to years

Class A fire – fire fuelled by solid carbonaceous materials

Class A foam – fire fighting foam designed for use with Class A fires

Class B fire – fire fuelled by combustible liquids

Class B foam – fire fighting foam designed for use with Class B fires

Closed-loop system – a system that virtually eliminates emissions to the environment i.e. reduces emissions below a specified level, usually the lowest concentration that can be measured

Combustible – able to catch fire at an intermediate temperature

Contained release – an event where discharge of a substance occurs but is contained so it does not have the potential to pollute the environment, e.g. fire fighting foam firewater that is fully contained in an impermeable bunded area

Contaminated site – a site with an elevated level of a chemical substance or waste leading to the risk, or potential risk, of adverse health or environmental impacts

Co-regulation – rules and codes of conduct set by industry with legislative backing from government to enforce these arrangements

Council of Australian Governments – the peak intergovernmental forum in Australia established to manage matters of national significance or matters that need coordinated action by all Australian governments

Dangerous goods – substances or items that present an immediate hazard to people, property or the environment because of their physical, chemical or acute toxicity properties, such as explosives, flammable liquids and gases, corrosives, chemically reactive or acutely toxic substances.

Decorative chromium plating – the use of chromic acid to apply a thin chromium surface layer to decorate products

Department of Environment and Energy or **the Department** – the Australian Government department responsible for environment and energy policy and programs

Dose-response – the change in effect on an organism caused by different levels of exposure to a chemical or other stressor

Economic instrument – a policy tool using positive and negative financial incentives to influence actions

Ecosystem – the interdependent interaction of all the living things and all the abiotic parts of the environment in a habitat

Effluent – a fluid released to the environment e.g. sewage or waste water

Electroplating – the application of a layer of metal onto an object by putting it into a tank containing plating solution and applying an electrical charge

End of life cost – the cost of disposal, termination or replacement of an asset or service

Endocrine – relating to the endocrine or hormone system in animals

Endocrine disruptor – chemicals that may interfere with the endocrine system in animals

Environment – the natural and human-made world, including the ecosystem, the built environment and the factors affecting human health and quality of life, but usually excluding economic and social matters

Environmental fate – where in the environment a substance travels to and what happens to it

Environmental impact – the effect on the environment from a product or activity

Epidemiology – the study of the distribution and causes of disease in human populations

Exposure – contact with a chemical assessed in terms of amount, duration and frequency of exposure

Fire fighting – suppression and extinguishment of fires to protect life, property and the environment

Fire fighting foam – a stable mass of bubbles made by mixing foam solution with air that is used to suppress fire

Foam concentrate – a liquid product that is mixed with water to form a foam solution

Foam solution – a solution of water and foam concentrate

Flammable – able to catch fire easily at a low temperature

Groundwater – water below the surface of the ground in the soil or in gaps within rocks, often located between saturated soil and the underlying rock

Half-life – the amount of time for something to be reduced to half its original value

Hard chromium plating – the use of chromic acid to apply a thick chromium surface layer to protect steel, used by the mining and automotive industries. Also known as hard metal plating

Hazard – inherent characteristic of a substance, object or situation that has the potential to cause harm

Hazardous chemical – a chemical that can have an adverse effect on health following exposure

Holistic – taking account of all relevant factors to produce the best possible outcome

Immunotoxicity – alteration to the function of the immune system increasing susceptibility to infectious disease or cancer

Industrial chemical – a chemical substance that has an industrial use

International law – laws and rules agreed between countries

Impermeable – not able to be passed through by liquids or gases

Law – rights, duties, powers and liabilities established by the common law, domestic legislation, customary international law and international treaties

Leachate – water that percolates through a solid and leaches out substances

Major hazard facility – a site where large quantities of hazardous materials or dangerous goods are stored, handled or processed.

Microgram – one millionth of a gram

Milligram – one thousandth of a gram

Mineralisation – the conversion of organic substances such as PFOS into simpler mineral or inorganic substances such as salts, water and carbon dioxide.

Mist suppressant – substance used to reduce the surface tension of a plating solution to prevent bubbles from bursting above the surface to form a mist

Mode of action – the cell-level changes caused by exposure to a substance

Natural capital – the sum total of environmental goods and services

Neurotoxicity – alteration to the function of the nervous system

Non-flammable – not able to catch fire easily or at a low temperature

Organisation for Economic Co-operation and Development (OECD) – an intergovernmental economic organisation with 35 member countries, including most of the world's advanced economies

Permeable – able to be passed through by liquids or gases

Persistent organic pollutant – organic compound with toxic properties that is be resistant to degradation in the environment

Plastics etching – the etching of plastic usually with a concentrated chemical such as chromic acid before electroplating

Plating solution – an electrolytic metal salt solution, such as chromium plating solution, used in electroplating

PFOS-containing – containing PFOS at a level above trace contamination

PFOS-related chemicals – chemicals containing the structural element PFOS in their molecular structure because they were produced with PFOS, its salts or PFOSF as an intermediate or starting material

PFOS stocks – PFOS in products that are still in use or stored for future use

Policy – a position or statement about an issue and the actions that are to be taken in response to the issue, e.g. a government policy

Policy instruments – tools used by government to implement policy and achieve policy goals, such as laws, regulations and economic instruments

Pollutant – a substance or energy with an adverse effect on the environment

Pollution event – an uncontained release of a substance into the natural or built environment with the potential to cause environmental harm

Polluter Pays Principle – principle that those who cause environmental damage should bear the costs of avoiding it, compensating for it or managing it

Pore water – water in the pores of soil or rock

Postnatal – occurring after the birth of an animal

Potable water – water that is suitable for human consumption without causing disease

Prenatal – occurring before the birth of an animal

Proving ground – site designed and used for safe trialling and testing of equipment or substances

Receptor – an organism or group of organisms exposed to a substance or environmental factor

Reference dose – the maximum acceptable oral dose of a toxic substance

Regulation – laws, rules and penalties set by government to restrict or prohibit harmful or potentially harmful activities

Regulations – subordinate legislation that provides details of how legislation is to be implemented

Risk – the likelihood that exposure to a hazard will cause an adverse outcome within a certain timeframe - in the environmental context this applies to outcomes in a person, group of people, plants, animals or the ecology of a specified area

Risk management – coordinated activities to improve performance in relation to risk

Runoff – water flow over the surface of the ground to the drainage system, such as a stream or river

Self-regulation – rules and codes of conduct set by industry or professional associations for their members

Service life – period of time after purchase and installation during which a device or building meets or exceeds its performance requirements

Sewage – a mixture of solid and liquid waste comprising human waste, water and other wastes – see the definition for waste water

Sewerage – system for removing sewage – see the definition for waste water system

Shelf life – period of time during which a product remains usable and meets or exceeds its performance requirements

Sludge – sediment or other mixtures deposited during sewage treatment

Subordinate legislation – a law passed to support the implementation of higher-level legislation; for an example, see the definition of regulations

Stormwater – rainwater and melt water running off surfaces

Surfactant – a substance that reduces the surface tension of a liquid and therefore acts as a detergent, wetting agent, emulsifier, foaming agent or dispersant

Treaty – agreement between two or more countries

Voluntary action – action taken by a business or individual without any coercion from an industry association, professional association or government

Waste – material left over from an industrial, manufacturing, agricultural, domestic or other human activity, especially unusable material

Waste management – collection, transport, recovery and disposal of waste, along with strategies that aim to reduce the likelihood of waste being produced

Waste water – water used for an industrial, manufacturing, agricultural, domestic or other human activity, including sewage, usually containing pollutants

Abbreviations

AFFF – aqueous film forming foam

CBA – cost-benefit analysis

CCD – charge-coupled device

LPOS – lithium perfluorooctane sulfonate

mg – milligram (one thousandth of a gram)

mg/kg – milligrams per kilogram

ml – millilitre

NEPM – National Environmental Protection Measure

NICNAS – National Industrial Chemicals Notification and Assessment Scheme

ng – nanogram (one billionth of a gram)

ng/g – nanograms per gram

OBPR – Office of Best Practice Regulation

PFASs – per- and poly-fluoroalkyl substances

PFCs – perfluorinated chemicals or perfluorocarbons

PFOA – perfluorooctanoic acid

PFOS – perfluorooctane sulfonic acid, perfluorooctane sulfonates, and related substances including perfluorooctane sulfonyl fluoride

PFOSF – perfluorooctane sulfonyl fluoride

POP – persistent organic pollutant

PV – present value

STP – sewage treatment plant