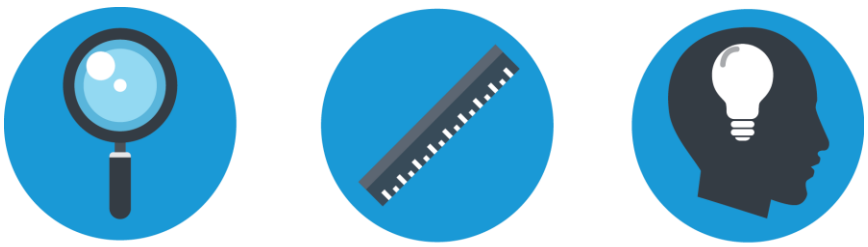
FIRST PERSON CONSULTING

Evaluation of the Air Program

Prepared for

Department of Planning and Environment



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Executive summary

The Air Program Evaluation

The objective of NSW government action on air pollution is "to improve average air quality results across New South Wales (NSW) to support public health and [the state's] continued growth and prosperity".[1] **The Air Program aims to contribute to this objective** by delivering air quality data, information and monitoring support for a variety of stakeholders.

The Air Program is run by the Climate and Atmospheric Sciences (CAS) branch within the Department of Planning and Environment (DPE). In 2017-18, CAS received a five-year tranche of $12.7 million from the Climate Change Fund (CCF) to support delivery of the Air Program. This funding was to:

- support the NSW Air Quality Monitoring Network, including expansion of the network
- update the pre-existing DustWatch monitoring network to form an integrated Rural Air Quality Monitoring Network
- enhance air quality forecasting in NSW
- deliver emergency incident response monitoring
- support delivery of the Sydney Air Quality Studies (SAQS)
- deliver the Clean Air by Design Projects, including setting up background air quality monitoring and enhancing the air quality monitoring website.

In line with Department of Premier and Cabinet requirements, **DPE commissioned this evaluation of the CCF-supported components of the Air Program.** The evaluation was broadly scoped to explore:

- the appropriateness of the program design and delivery to date
- effectiveness of the program management to date
- progress towards achieving outcomes and targets
- lessons learnt and adaptive management to date.

Our approach to the evaluation included:

- **Preliminary interviews with 14 program staff**, focused on the scope of the program components, lessons from delivery and insights on outcomes and impacts.
- **Interviews with 34 key stakeholders** to explore broader perceptions on delivery and outcomes from the Air Program. This included staff from other government agencies, researchers and other users of program data and services.
- **A survey to collect data from website and alert/forecast subscribers**. A link to this short survey was put on the DPE air quality website and sent to subscribers who have chosen to receive emails and SMS forecasts on a daily basis. The survey was available from late-February until mid-April and received 179 usable responses.
- **Review of program documents**, including
    - website analytics, subscriber statistics and forecast logs
    - publications and other outputs from the CAS branch
    - the CCF business case and five-year project plans for the Sydney Air Quality Studies and the Enhanced Forecasting projects
    - excerpts from internal status reports about the project.

[1] Clean Air for NSW CCF Business Case – Improved information on the exposure of communities to air pollution at local scales. p. 12

Key findings

Through delivering the Air Program, the CAS branch team has made a broad range of improvements to the NSW air quality monitoring network and the science underpinning air quality monitoring and forecasting. This has contributed to enhanced understanding of air quality among the community and key stakeholders. In turn, this has helped to inform air quality policies, air quality management and individual behaviours that reduce exposure to pollution.

Some of the main achievements have been:

- **The air quality monitoring network in NSW has been substantially expanded**. There are 20 new monitoring sites compared to 2016, including eight sites in major regional NSW towns and five in Sydney. Excluding improvements in Sydney, 9% of the NSW population has more granular air quality information. 4% of the NSW population now has access to air quality monitoring in regional townships where there was none previously.
- **The existing DustWatch network has been upgraded and integrated into the broader statewide monitoring network.** There are now 33 sites across rural NSW.[2] Stations are also now capable of monitoring PM2.5 particles and providing data in near-real-time.
- **There have been substantial upgrades and improvements to the air quality website and associated communications.** This includes a new, dedicated NSW air quality site. There has been good feedback that the website is more user-friendly and accessible than it was previously. Other key changes include the use of clearly (and nationally consistent) colour-coded air quality conditions and air quality concentration data has been shifted to be displayed in hourly averages.
- **The accuracy of air quality forecasting is** improving and the underlying air quality modelling approach has been updated in line with the most advanced European and US models.
- **Emergency incident monitoring stations have been used extensively through the Air Program,** for example, nine stations were deployed during the Black Summer bushfires to help monitor air quality and support agencies managing the fires.
- **The Sydney Air Quality Studies** have delivered a comprehensive assessment of the trends and sources of pollution in the Sydney metropolitan region. This analysis has underpinned the recently released NSW Clean Air Strategy 2021-2030 and is soon to be complemented with a second analysis outlining the health impacts of air pollution.

There is good evidence that the ongoing operation of the Air Program, combined with the expansion and enhancements noted above, is flowing through to on-ground impacts. In particular:

- **1000s of people use the website and/or the forecasting and alert services on a daily basis.** During the Black Summer bushfires in late 2019 and early 2020, daily website use was around 35 times the average. New subscribers to alerts during this period account for two-thirds (67%) of all the subscriptions over the last five years.
- **86% of surveyed website users and alert subscribers are satisfied with the information available**
    - 95% regularly use it to help make decisions/manage their exposure
    - 99% indicated that the data and alerts are important.
- All of the interviewees who discussed the quality of the data from the DPE website (17) were satisfied with its quality.

[2] plus six interstate that act as nearby/early warning stations

In terms of broader decisions relating to air quality, the Air Program appears to be delivering information about:

- Air quality trends, population exposure and impacts to inform decisions about air quality policies – this includes the NSW 2021-2030 Clean Air Strategy and tightening of air quality standards at the national-level.
- Air pollution incidents and emergencies to help inform public health advice and management of the situation by emergency services.
- Air quality forecasts and advice to help plan and manage hazard reduction burns to minimise adverse impacts from smoke.
- Air quality in particular areas to inform decisions about the regulation or compliance of licenced emitters or planning approvals, a key example being supporting decision-making about strengthening the emission standards for the Vales Point power plant.
- Dust and smoke in regional areas as indicators for guiding and improving agricultural practices.

While there have been a broad range of improvements and outputs created under the Air Program, not all of the program components appear to have been delivered as planned. One of the key issues here appears to be a lack of a clear program plan and deliverables. **Acknowledging that the program still has three months to run, two key areas that do not yet appear to have been completed are**:

- Enhanced air quality forecasting. Although DPE staff noted there has been extensive work on and improvements to the underlying modelling frameworks, **the objective of delivering forecasts for outside the Sydney area has not yet been achieved** (is still under development).
- Although the EWADD project has made substantial improvements to the website interface as well as progressing some of the underlying infrastructure**, the project is still being delivered and has required substantial additional resources.**

Some of the general challenges contributing to these issues include:

- delays created by the Black Summer bushfires in 2019/2020, which drew resources away from projects into substantially increased demand for monitoring, forecasting and communication work.
- a general raising of expectations with respect to the availability and coverage of air quality monitoring data.
- uncertainty for people employed on temporary contracts.
- limited computing resources required for modelling and forecasting work
- lack of clarity in process, roles and responsibilities in managing IT projects
- the underlying technical challenges of working on complex subject matter.

These challenges aside, the Air Program benefited from several structures and approaches that supported delivery and are important to recognise for future work in this space. Key enablers were:

- the Air Program has a well-established set of systems, processes and people honed developed over several decades
- collaboration has been important in accessing appropriate expertise.
- there is a strong culture of professionalism and hard work among CAS branch team members
- there is a good level of openness to adapting and responding to feedback, particularly with respect to the website and other key communications.

Summary of recommendations

Based on the key findings above and the more detailed results in the remainder of the report, we recommend:

1. As DPE continues to manage and refine the air quality monitoring network, **it should clarify what the different goals of the network are and how they might be served by different types of station and approaches to monitoring**. While the air monitoring plans go some way towards this, they would benefit from clearer articulation of what information the network needs to produce and, in turn, what outcomes it is hoping to achieve.
2. In addressing Recommendation 1, **there would be value in developing a more detailed theory of change for stakeholders who are expected to use the outputs of the Air Program and monitoring network**. The current Air Program logic clearly articulates the high-level outcomes it is working towards. It would benefit, however, from having more detail about the shorter- and medium-term outcomes.
3. **DPE should consider strengthening its approach to communicating with end-users**. Producing information is a key part of the work of the branch but there is further opportunity to make sure this information is distributed to and understood by those who might need it.
4. **Future programs and tranches of work that use external funding should be designed and managed more transparently**. This includes developing a program plan with clear objectives, timelines, budgets and governance structures. DPE may consider identifying a central responsible person for managing the program, rather than coordination happening across teams via the branch director.
5. **To help identify objectives in future projects, there may be value in identifying specific underlying problems**. This has been done to some extent in the current program, though the problems are articulated at a very high level.
6. **DPE should consider developing a research plan/strategy for the CAS branch**. Although the work of the team appears to be far-reaching, it is not clear what is being worked on and if and how it might be relevant to policy and other decision-makers.
7. **DPE should consider developing a range of more detailed reports on program expenditure, including how much staff time is allocated to different activities.** This would be useful in assessing where resources are flowing and what the relative cost-effectiveness is of different activities within the branch.

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1 Introduction

1.1 Background

The objective of New South Wales (NSW) government action on air pollution is "to improve average air quality results across New South Wales to support public health and [the state's] continued growth and prosperity".[3] The Air Program aims to contribute to this objective by delivering air quality data, information and monitoring support that is timely and fit-for-purpose for a variety of stakeholders.

The Air Program is run by the Climate and Atmospheric Science (CAS) branch within the Department of Planning and Environment (DPE). In 2017-18, CAS received a five-year tranche of $12.7 million from the Climate Change Fund (CCF) to support delivery of the Air Program. Running out to mid-2022, this funding was to:

- support the NSW Air Quality Monitoring Network, including expansion of the network
- update the pre-existing DustWatch monitoring network to form an integrated Rural Air Quality Monitoring Network
- enhance air quality forecasting in NSW
- deliver emergency incident response monitoring
- support delivery of the Sydney Air Quality Studies (SAQS)
- deliver the Clean Air by Design Projects.

These activities seek to build knowledge, enhance government programs and support decisions on personal, public and environmental health. In turn, the program contributes to the broader goal of improving the resilience of communities, government and businesses to the effects of air pollution.

In line with Department of Premier and Cabinet requirements, DPE commissioned First Person Consulting (FPC) to evaluate the Air Program.

1.2 Objectives and scope of the evaluation

The purpose of the evaluation is to determine:

- the appropriateness of the program design and delivery to date
- effectiveness of the program management to date
- progress towards achieving outcomes and targets
- lessons learnt and adaptive management to date.

The scope of the work includes:

- liaison with DPE teams to collate data and contacts for the evaluation
- collection and collation of additional data and information
- development of a summative evaluation report of the program in line with the CCF Evaluation Framework and fit-for-purpose for the size of the program
- recommendations for program improvement which may inform future program design under future rounds of CCF funding or other NSW Government funding.

[3] Clean Air for NSW CCF Business Case – Improved information on the exposure of communities to air pollution at local scales. p. 12

As per the Air Program Evaluation Plan, some components of the Air Program are not included in this evaluation (i.e. those not receiving CCF funding) (Table 1). The evaluation is focused on the period 1 July 2017 to 30 June 2022. Out-of-scope for this evaluation is:

- evaluation of the performance of individual projects
- a full cost and benefit analysis (CBA) of the Air Program.

Table 1. Components of the Air Program that are in/out of scope for this evaluation. (from Air Program Evaluation Plan)[4]

Program component	Funding Source	In scope of evaluation under CCF?
1) NSW Air Quality Monitoring Network (excluding industry-funded networks)	Treasury-tied funding / WELE / CCF	Yes
2) Rural Air Quality Monitoring Network	Partly funded by EPA, LLS, CCF	Yes
3) Enhancing Air Quality Forecasting in NSW	CCF	Yes
4) Sydney Air Quality Studies	CCF	Yes
5) Clean Air by Design Projects (Clean Air for NSW CCF Business Case Actions 1, 3 and 4)	CCF	Yes
6) Emergency incident response monitoring	Various sources	Yes
7) Upper Hunter Air Quality Monitoring Network	Industry-funded	No
8) Newcastle Local Air Quality Monitoring Network	Industry-funded	No
9) Namoi Air Quality Monitoring Network	Industry-funded	No
10) Broken Hill Environmental Lead Study	EPA/WELE	No
11) Research/campaign monitoring projects	Various sources	No

1.3 This document

This document reports on the findings of the Air Program evaluation, including:

- our **methodology** for the evaluation (Section 2)
- **background** and structure of the Air Program (Section 3)
- the **design and delivery** of the Air Program (Section 4)
- **effectiveness of the program in delivering information** where it is needed (Section 5)
- **effectiveness of the program in improving decisions** on environment and public health (Section 6)
- **other outcomes** and value for money (Section 7)
- a **summary of key findings and recommendations** (Section 8)

[4] Air Quality Program – Evaluation Plan. NSW Department of Planning, Industry and Environment. June 2021.

2 Methodology

2.1 Overview

The broad steps in our approach to this evaluation are outlined below, with details of the key evaluation questions and indicators considered (based on the CAS branch's Air Program Evaluation Plan) provided in Appendix A:

- At the start of the project in January 2022 **we met with DPE staff central to the evaluation**. This meeting was used to clarify the overall objectives for the evaluation, agree on our general approach and identify logistical processes and expectations.
- Following the meeting we **developed a project plan** for the evaluation, building off the existing Air Program evaluation plan (key evaluation questions are outlined in Table 2).
- Only limited program documentation was available at the early stages of the evaluation. As such, **we planned an iterative approach to data collection that included**:
    - **Preliminary interviews with key program staff**, focused on the scope of the program components, lessons from delivery and insights on outcomes and impacts.
    - We then did successive rounds of **interviews with key stakeholders** as our understanding of the program improved (Table 3).

  All interviews were done by phone or video-conference and were semi-structured, allowing for a range of issues to be explored depending on their involvement with the program.
- In addition to interviews, **we also developed a survey (Appendix C) to collect data from website and alert/forecast subscribers**. A link to this short survey was put on the DPE air quality website. The survey link was also sent to all subscribers who have chosen to receive emails and SMS forecasts on a daily basis. The survey was available from late-February until mid-April and received 179 usable responses.
- **We presented the initial results** from interviews and surveys to the DPE team on 16 March to provide an update on progress as well as being an early sense-check of the findings.
- On 16 March **the DPE team provided a full set of program documents** (noting that some of these documents were available earlier in the evaluation). This included a broad range of material such as:
    - website analytics, subscriber statistics and forecast logs
    - publications and other outputs from the CAS branch
    - the CCF business case and five-year project plans for the Sydney Air Quality Studies and the Enhanced Forecasting projects
    - examples of correspondence between DPE and key stakeholders
    - excerpts from internal status reports about the project.
- **We analysed the available data** with reference to the key evaluation questions. This included a thematic analysis of the interviews and simple descriptive analysis of the survey results.
- After analysis, **we developed this evaluation report**. We also presented the results to key stakeholders within the branch on 4 May before integrating comments, feedback and additional insights into the final report.

Table 2. Evaluation questions and sub-questions. The original evaluation framework is provided with FPC notes in Appendix A.

Focus area	Evaluation questions	Sub-questions
Program delivery	KEQ1: How has the design of the program supported efficient delivery?	1.1 What worked well? 1.2 What were the barriers to efficient delivery and what improved success?
	KEQ2: To what extent does the program deliver the right information to the right people, and at the right time?	2.1 How well were the projects delivered by the program strategically relevant to end-user needs (NSW government policies, priories and strategies)? 2.2 To what extent was information widely diffused to business, community and susceptible population sub-groups? 2.3 Do end-users and communities (*including population sub-groups*) have confidence in the quality, accessibility, *usefulness* and timeliness of program services?
Outcomes and effectiveness	KEQ3: To what extent has the program achieved improved decisions on environment and public health?	3.1 To what extent have the program outputs been adopted to improve air pollution management policies and programs? 3.2 To what extent have people used/likely to use the information to reduce their personal exposure to air pollution?
	KEQ4: To what extent does the program present value-for-money?	
	KEQ5: Were there any positive or negative unintended outcomes from the program?	5.1 What were the positive unintended outcomes of the program? 5.2 What were the negative unintended outcomes of the program?

Table 3. Breakdown of stakeholders interviewed for Air Program evaluation.

Stakeholder group	Number
DPE CAS branch staff	14
Other DPE staff	6
EPA staff	5
RFS and NPWS staff	7
NSW Health	4
Researchers	10
Interstate government representatives	4
Total	50

2.2 Limitations

There are a range of limitations to this evaluation that should be kept in mind:

- **A large portion of the evidence presented is based on the feedback from interviews and/or survey respondents**. It is, therefore, inherently subjective and may be subject to biases. We have tried to address this by interviewing a broad range of stakeholders involved or associated with the program as well as triangulating results against documents and other data where possible.
- **The survey, in particular, should be seen as representative only of stakeholders who are heavily engaged in the program** outputs, rather than a representative sample of all website users/subscribers.
- **The program lacks a range of high-level documents that might be typically expected for a program of this scale and nature**. I.e. there was no overarching program plan and the information in project-level plans, where available, was limited. Only high-level budget information was available. We understand that these limitations are the result of the program being largely 'business-as-usual' activities, rather than a unique piece of work that has been designed and funded as a separate initiative. While this is understandable, it has created challenges in our ability to clearly identify program objectives, targets and activities.

3 Overview of the Air Program – structure and key components

3.1 Organisational context

The CCF-funded components of the Air Program sit within a broader hierarchy of organisational activities and objectives (Figure 1).

At the most general level, the CAS branch's purpose is: [5]

> *To deliver NSW Government priorities in climate, net zero emissions and air quality science, identify emerging research needs, and providing the Government, decision makers and the public with information on regional greenhouse gas emissions, climate change and air quality.*

This is about better understanding the atmospheric environment and assisting decision-makers in dealing with the complex policy issues of air pollution and climate change. **There are six teams within the CAS branch**:

- Air Quality Monitoring
- Calibrations
- Quality Systems and Reporting
- Atmospheric Research
- Net Zero Emissions (not part of this evaluation)
- Climate Research (not part of this evaluation).

These teams deliver a range of services. This includes both outward facing projects, such as NSW/ACT Regional Climate Modelling (NARCliM), Greenhouse Gas Emission Tracking, Net Zero Emission Modelling and air quality monitoring data, as well as advancing the science underpinning these outputs. Of note is that these teams are all connected – particularly among the first four relevant to the Air program – their work and their outputs are important to each other and the functioning of the branch as a whole.

[5] Climate and Atmospheric Science Branch Operations Plan March 2021-June 2022.

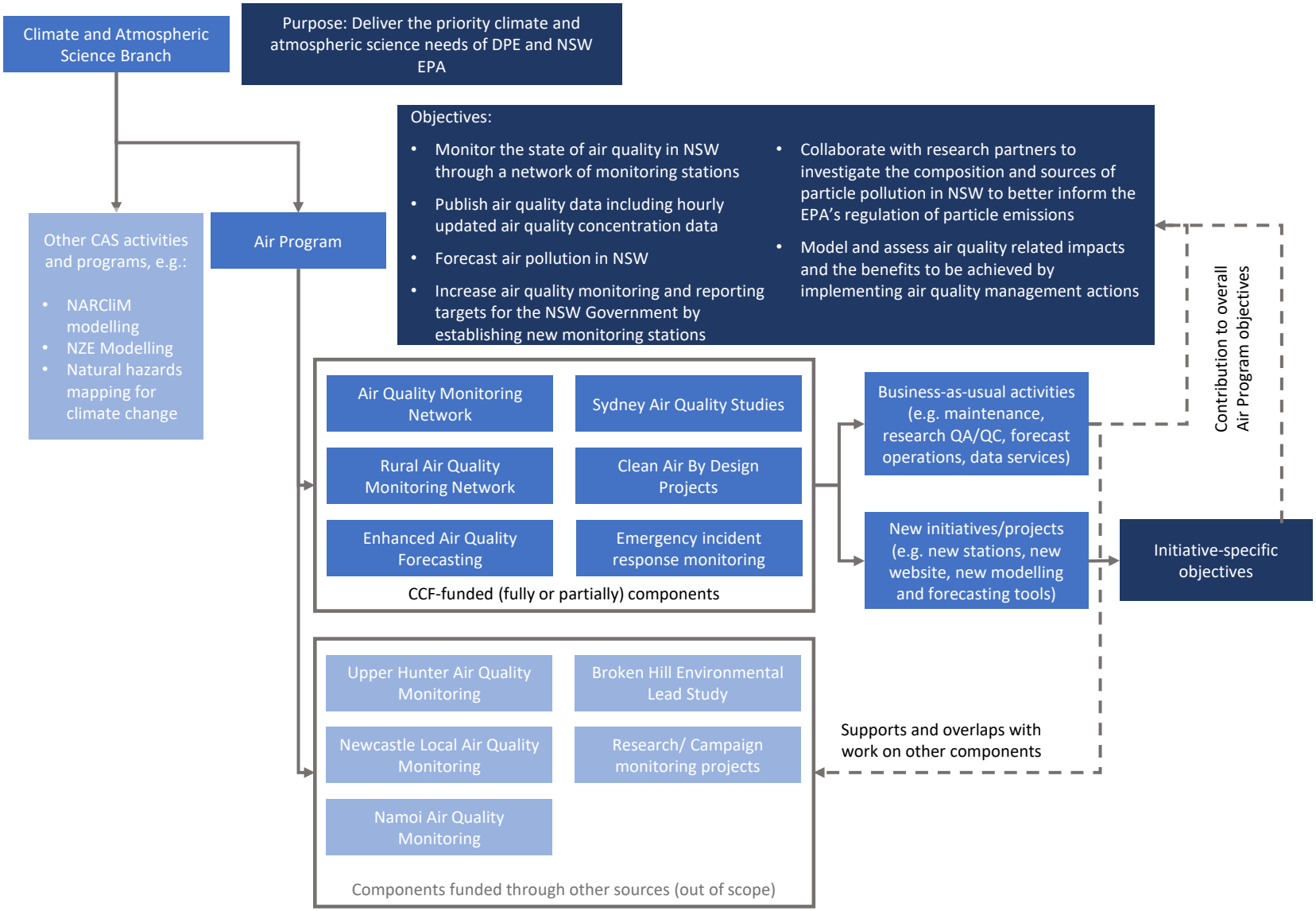

Figure 1. Air Program components within the context of the Climate and Atmospheric Science Branch.

3.2 The Air Program

Among the different activities delivered by the CAS branch, the Air Program has been in place for over 60 years. As per the DPE website, the Air Program logic and the CCF evaluation plan, **the objectives of the Air Program for the period relevant to this evaluation are to**:[6]

- **monitor the state of air quality** in New South Wales through a network of monitoring stations
- **publish air quality data** including the hourly updated air quality concentration data
- **forecast air pollution** in New South Wales
- **increase air quality monitoring and reporting targets** for the NSW Government by establishing new monitoring stations in the state
- collaborate with research partners to **investigate the composition and sources of particle pollution** in New South Wales to better inform the EPA's regulation of particle emissions
- **model and assess air quality related impacts** and the benefits to be achieved by implementing air quality management actions.

In turn, the Air Program aims to deliver three key high-level impacts, as articulated in its program logic (Figure 2):

- **improved air quality** across New South Wales
- **strengthened air quality management** to reduce air pollution and exposure NSW
- **improved resilience of community and business to climate change, environmental hazards and risks**.

The Air Program is a mix of:

- business-as-usual services and processes (that also contribute to or overlap with other areas of work within the CAS branch)
- discrete projects and initiatives designed to enhance the monitoring and forecasting work being done by the Branch (e.g. upgrades to the website, additional stations, integration of the DustWatch network, new modelling and forecasting systems).

It is delivered across four of the six CAS teams and has 11 components (Figure 1, Table 1). Further complicating the structure of the Air Program is that it receives funding from a range of sources. This includes a tranche of funding between 2017-2022 that was supplied by the CCF, rather than from treasury recurrent funding, from which it has been provided previously. This required the CAS branch to develop a specific business case for these CCF-linked funds[7] (and required this evaluation).

Given the mix of business as usual and discrete initiatives and the interrelationship between the Air Program and other elements of the CAS branch's work, it is an unusual 'program' from an evaluation and CCF perspective. Notably, it does not have an overarching (classic) program plan or governance structure - rather, it is has been managed through (and as part of) the CAS branch Quality Management System (QMS), where the key pilar processes are set for the Air Program, including the air quality monitoring, modelling and reporting.

[6] based on program logic and website content at: https://www.environment.nsw.gov.au/topics/air/about-the-air-program [accessed 25 March 2022] and Air Quality Program – Evaluation Plan. NSW Department of Planning, Industry and Environment. June 2021.

[7] Clean Air for NSW CCF Business Case: Improved information on the exposure of communities to air pollution at local scales. Office of Environment and Heritage.

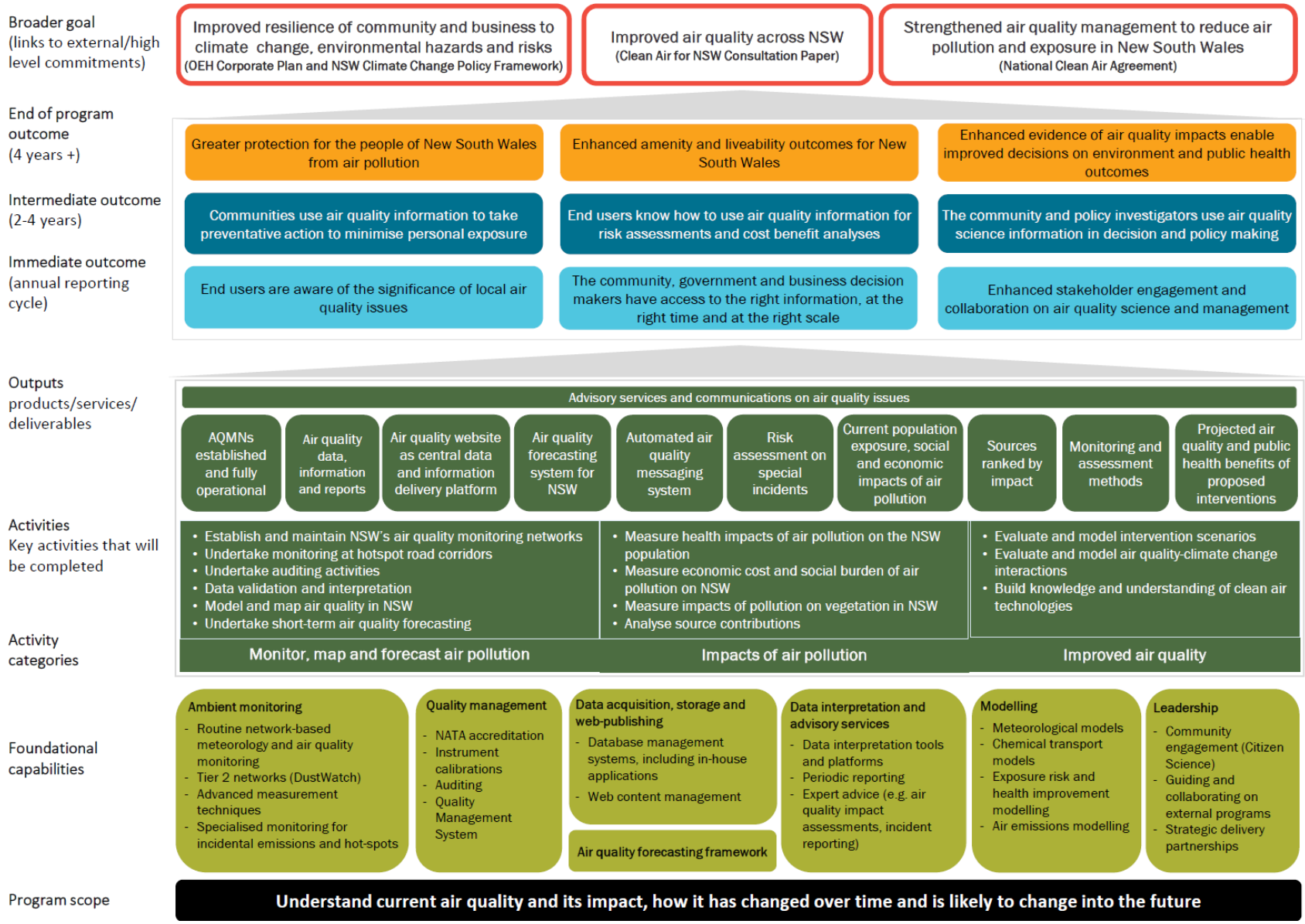

Figure 2. Program logic for the Air Program. Sourced from https://www.environment.nsw.gov.au/topics/air/about-the-air-program

3.3 Objectives and details for the Air Program components

In the absence of an overarching plan or framework for the Air Program, we have compiled a picture of the Air Program components and their objectives based on a combination of Branch-, component- and project-level sources. This is outlined in Table 4. This is important in understanding and demonstrate what the CCF-funds have meant and contributed to, beyond the broad objectives of the Air Program noted in Section 3.2 above.

Of note is that the CCF business case (Clean Air for NSW) does not itself have a clearly articulated objective. It notes:

> *The objective of government action is to improve average air quality results across NSW to support public health and NSW's continued growth and prosperity*[8]

This is, however, a broader objective for action in this space, rather than relating to the specific work being done under the CCF-funded components of the Air Program. The clearest articulation of what the CCF-funds are supporting is:

> *… actions … [to] ensure that NSW Government, businesses and residents will be aware of the long and short-term impacts of air pollution and will have access to the best available tools and information, at a scale and in a form, relevant to them.*[9]

Ultimately, **as noted in the business case, this is about "better information on air pollution and its impacts"**.

One final source of guidance on what the Air Program is expected to deliver comes from excerpts from internal reporting for 'CCF34: Air quality monitoring and reporting'. This points to five actions:

1. Establish air quality monitoring in Sydney, Parramatta, and Penrith.
2. Enhance the NSW rural air quality monitoring network.
3. Establish a baseline air quality monitoring station in rural NSW.
4. Enhance the EES air quality website and data delivery.
5. Provide state-wide air quality forecasting and alerts.

These reflect some of the components outlined in the CCF Business Case and the Air Program evaluation framework. They do not, however, capture all of the funding or provide more detailed insights on what is expected to be delivered against each of these actions. We have integrated these actions into Table 4 below.

[8] Clean Air for NSW CCF Business Case: Improved information on the exposure of communities to air pollution at local scales. Office of Environment and Heritage. p. 12
[9] Clean Air for NSW CCF Business Case: Improved information on the exposure of communities to air pollution at local scales. Office of Environment and Heritage. p. 12

Table 4. CCF-funded components of the Air Program and consolidated initiatives/actions and objectives. *These related actions are sourced from excerpts from internal reporting for *CCF34: Air quality monitoring and reporting*.

Component	Key initiatives/ actions/ projects	BaU or new	Objective / purpose	Related Air Program overarching objective	Related action from program reporting*
NSW Air Quality Monitoring Network (excluding Rural Air Quality Monitoring Network, industry-funded networks)	Operation of the Sydney and regional Air Quality Monitoring Network	BaU	Fulfilment of NSW Government's legislative requirements. Generates data to support decision-making by government and the community, ranging from short-term behaviours by the public to reduce their exposure, through to long-term policies designed to reduce air pollution. Includes maintenance, calibration, quality-control of data and longer-term planning around site placement	Monitor the state of air quality in New South Wales through a network of monitoring stations	None
	Reporting on AQMN data	BaU	Fulfils reporting obligations on air quality (e.g. against the National Environmental Protection (Ambient Air Quality) Measure (AAQ NEPM), the NSW State of the Environment, or the Australian State of the Environment).	Publish air quality data including the hourly updated air quality concentration data	None
	Communication of air quality data through the DPE website and alert service	BaU	Communicates information to help members of the public make decisions. Enhanced through Clean Air by Design Action 4	Publish air quality data including the hourly updated air quality concentration data	None
	Expansion of the network to new sites	New	See Clean Air by Design Action 1	Increase air quality monitoring and reporting targets for the NSW Government by establishing new monitoring stations in the state	1. Establish air quality monitoring in Sydney, Parramatta, and Penrith.
Rural Air Quality Monitoring Network	Upgrade of monitoring nodes to incorporate PM2.5 and near-real-time data	New	To increase the proportion of the NSW population that has air quality monitoring data available.	Monitor the state of air quality in New South Wales through a network of monitoring stations	2. Enhance the NSW rural air quality monitoring network.

Component	Key initiatives/ actions/ projects	BaU or new	Objective / purpose	Related Air Program overarching objective	Related action from program reporting*
	Integration of monitoring network operation into CAS branch, including relocation of some nodes	BaU/ New	Note: the activities relating to the Rural Air Quality Monitoring Network are listed under Action 2 of the CCF Business Case.	Publish air quality data including the hourly updated air quality concentration data	2. Enhance the NSW rural air quality monitoring network.
Enhancing Air Quality Forecasting in NSW	Update and improve the air pollution forecasting system	BaU/ New[10]	Note: the activities relating to Enhancing Air Quality Forecasting are listed under Action 5 of the CCF Business Case. As per the Enhancing Air Quality Forecasting in NSW project plan, the aim is to enhance CAS's forecasting capability, including the accuracy of forecasts.	Forecast air pollution in New South Wales	5. Provide state-wide air quality forecasting and alerts.
	Expand forecasts to cover other regions in NSW (i.e. beyond Sydney)	BaU/ New	Under the CCF Business Case, this action aimed to provide all major NSW communities and Government agencies have access to air pollution forecasts.	Forecast air pollution in New South Wales	5. Provide state-wide air quality forecasting and alerts.
Sydney Air Quality Studies	A collection of studies on Sydney air quality trends, population impacts, pollution sources, and potential interventions	BaU/ New[11]	"…collating and expanding the evidence base to address knowledge needs related to air quality and its impacts in the Greater Sydney region, and identification of feasible opportunities to realise public health benefits".[12]	Collaborate with research partners to investigate the composition and sources of particle pollution in New South Wales to better inform the EPA's regulation of particle emissions Model and assess air quality related impacts and the	None

[10] There is a project plan (Enhancing Air Quality Forecasting in NSW - *Air Quality Forecasting Project Plan (5 year) 20170306.docx*) and 5-year funding allocation ($2.7 million). However, the project plan refers to work done from 2013 onwards and staff indicated that the Air Quality Forecasting Framework is an ongoing initiative.
[11] While this has a discrete project plan (Sydney Air Quality Studies - *Sydney Air Quality Study Project Plan (5 year) 20170306.docx*) and 5-year funding allocation ($3.3 million), the project plan refers to work done from 2015 onwards.
[12] Sydney Air Quality Study Project Plan. p. 1

Component	Key initiatives/ actions/ projects	BaU or new	Objective / purpose	Related Air Program overarching objective	Related action from program reporting*
				benefits to be achieved by implementing air quality management actions	
Clean Air by Design Projects (Clean Air for NSW CCF Business Case Actions 1, 3 and 4)	Action 1 - Establish air quality monitoring in the three cities CBDs (i.e. expansion of the Sydney air quality monitoring network)	New	According to the CCF Business Case, "information on current air pollution in the Sydney and Parramatta CBDs is limited … the expansion of air quality monitoring into the CBDs will allow the NSW Government to better understand air pollution exposure in the places where the most NSW people work, live and play."[13]	Monitor the state of air quality in New South Wales through a network of monitoring stations Increase air quality monitoring and reporting targets for the NSW Government by establishing new monitoring stations in the state	1. Establish air quality monitoring in Sydney, Parramatta, and Penrith
	Action 3 – Baseline air quality monitoring station	New	Establish a baseline air quality monitoring station in an appropriate location (e.g. Warrumbungle National Park). The CCF Business Case notes "There is limited information about background air pollution in rural and regional NSW and [DPE] does not have a baseline air quality monitoring station to provide background (natural) air pollution levels".[14]	Monitor the state of air quality in New South Wales through a network of monitoring stations Increase air quality monitoring and reporting targets for the NSW Government by establishing new monitoring stations in the state	3. Establish a baseline air quality monitoring station in rural NSW
	Action 4 – Enhance the air quality website and data delivery	New	Key points from the CCF Business Case were: • "Update the OEH air quality data pages to provide access to all air quality and meteorology data, including 1-hour and 1-min averages	Monitor the state of air quality in New South Wales through a network of monitoring stations	4. Enhance the EES air quality website and data delivery.

[13] Clean Air for NSW CCF Business Case: Improved information on the exposure of communities to air pollution at local scales. Office of Environment and Heritage. p. 12
[14] Clean Air for NSW CCF Business Case: Improved information on the exposure of communities to air pollution at local scales. Office of Environment and Heritage. p. 13

Component	Key initiatives/ actions/ projects	BaU or new	Objective / purpose	Related Air Program overarching objective	Related action from program reporting*
			• Expand the website to include near-real time updates of air quality data from the DustWatch network • Make historic NSW air quality data reports and research available digitally • Develop an open-access API for NSW air quality monitoring data to be freely served through the SEED portal, supporting researchers and development of third-party applications for the data"[15]. Although not explicitly noted in the Business Case, the Enhanced Website and Data Delivery (EWADD) project also involved substantial upgrades to the logging and telemetry systems of the air quality monitoring network. This provides the system with the ability to continue to deliver on the demands of near-real-time and network expansion as scoped in the business case.	Publish air quality data including the hourly updated air quality concentration data	
Emergency incident response monitoring	Operation of incident response monitoring	BaU	The CCF-funding did not support any additional/separate objectives with respect to emergency incident monitoring. However, operation of the emergency incident monitoring is supported through contingencies within the air quality monitoring network budget, which is supported by CCF-funding (and other sources).	Monitor the state of air quality in New South Wales through a network of monitoring stations	None

[15] Clean Air for NSW CCF Business Case: Improved information on the exposure of communities to air pollution at local scales. Office of Environment and Heritage. p. 14

4 Design and delivery of the Air Program

4.1 Overview

This section addresses how well the program has been delivered, including what design elements have supported delivery. We broadly discuss:

- What components have been delivered and the key achievements (Section 4.2)
- What worked well in terms of delivery (Section 4.3).
- What the barriers and challenges have been to delivery (Section 4.4).

4.2 How well delivery has worked

The Air Program does not have an overarching program plan or schedule of milestones, outputs or deliverables. It is, therefore, difficult to assess how well it has been delivered in relation to achievement of key targets or requirements. The only feedback that we have in this respect is high-level – i.e. comments from DPE staff against key program actions (Table 5). **This suggests that, overall, the program has largely been delivered in line with the original intent.** However, there are still some key outstanding items that are still in the process of being delivered.

The key enablers and challenges to delivery are outlined in Sections 4.3 and 4.4, respectively.

The Air Program Evaluation Plan suggested a performance metric and expectation of "90% of projects delivered, or program milestones have been reached within planned/agreed timeframe and budget". Unfortunately we were unable to directly assess this as there was not a discrete list of projects/milestones with timing or associated budget/expenditure data (see Appendix D for summary against all performance indicators/expectations).

The second performance metric related to program design and deliver was "Evidence that end-users requested air quality data and information services". This is discussed more in Section 5.3, where there is clear evidence that end-users want and ask for air quality data and information services.

Table 5. High-level feedback on key components/deliverables. Indicative progress is based on feedback from stakeholder interviews supported, where available, with program documentation.

Component	Key initiatives/ actions	Indicative progress	Achievement / Comment
NSW Air Quality Monitoring Network (excluding industry-funded networks)	Operation of the Sydney and regional Air Quality Monitoring Network	Delivered as per BaU	
	Reporting on AQMN data	Delivered as per BaU	
	Communication of air quality data through the DPE website and alert service	Delivered as per BaU	The DPE website has had substantial enhancements as noted below
Rural Air Quality	Upgrade of monitoring nodes to incorporate PM2.5 and near-real-time data	Complete	The rural network now has 39 sites, records PM2.5 particles and updates the website in near-real-time.

Component	Key initiatives/ actions	Indicative progress	Achievement / Comment
Monitoring Network	Integration of monitoring network operation into CAS branch, including relocation of some nodes	Complete	
Enhancing Air Quality Forecasting in NSW	Update and improve the air pollution forecasting system	Appears to be complete/ mostly complete	Enhancement of air quality forecasting was noted to be an ongoing activity within the branch. There appears to have been good progress here in building state-of-the-art models within the 2018-2022 period, though the ultimate outputs (additional forecasting products) are still under development.
	Expand forecasts to cover other regions in NSW (i.e. beyond Sydney)	In progress	The public interface is being built and expected to be ready by June 2022 (originally by 2021 but delayed due to cyber security issues with the supplier side)
Sydney Air Quality Studies	A collection of studies on Sydney air quality trends, population impacts, pollution sources, and potential interventions	Complete	Two stages of work have been delivered: • trends and sources of air pollution in Sydney • health impact assessments from air pollution
Clean Air by Design Projects (Clean Air for NSW CCF Business Case Actions 1, 3 and 4)	Action 1 - Establish air quality monitoring in the three cities CBDs (i.e. expansion of the Sydney air quality monitoring network)	Complete	20 new stations have been installed in total, including 3 in the city CBDs, 2 in other parts of Sydney, 8 in regional towns, 1 roadside monitor and 6 rural air quality sites
	Action 3 – Baseline air quality monitoring station	Appears to be complete/ mostly complete	Research on what an appropriate baseline air quality monitoring site/design might look like. [16] Merriwa site upgraded from PM10 monitoring site to measure CO, NOx, SO2, O3, PM10, PM2.5, Neph, Black Carbon and precipitation as a baseline air quality monitoring station in August 2020.
	Action 4 – Enhance the air quality website and data delivery	In progress	Air quality data API was developed and put into operation - published on the DPE website and SEED. The new website has been redeveloped (Stage 1) though the back-end upgrades to database and telemetry systems (Stage 2) has been delayed (in progress).
Emergency incident response monitoring	Operation of incident response monitoring	Delivered as per BaU	There has been a wide range of deployments during the program, including:

[16] Design of a background air quality monitoring station. May 2019. Northstar Air Quality Pty Ltd for NSW Government Office of Environment and Heritage

Component	Key initiatives/ actions	Indicative progress	Achievement / Comment
			• nine stations during the 2019-20 fires • a fire at the Lismore Recycling and Recovery Centre • research monitoring in the Blue Mountains • an underground fire at Kooragang Island This capability has been enhanced by establishment of additional modelling tools and forecasting capabilities.

4.3 Aspects of the program that worked well to support delivery

There are a range of elements that have combined to support delivery of the Air Program. First and foremost is that **the Air Program has benefited from a well-established set of systems, processes and people. This has been critical to delivery of the program between 2017 and 2022.** This includes:

- The systems that work to support the air quality monitoring network and associated reporting, including the CAS branch's Quality Management System. This includes elements such as the Air Program logic model, standard operating procedures, the air program quality assurance manual, annual quality/business objectives, calibration and maintenance processes, data validation and other quality management processes.
- It also includes the existence of the monitoring network itself. The network has been in place for over 60 years and, along with the supporting processes noted above, has been added-to, adapted and refined over that time.
- Lastly the program has benefited from the skills and experience of the CAS branch staff. The team is largely made up of either scientists who have had years (or decades) working within the branch or have come from other specialist air quality monitoring positions. As with the systems noted above, this is important human capital that supports delivery of the program.

With these elements already in place, the CCF-funded components of the Air Program have been able to largely focus on building and enhancing the air monitoring network and forecasting and its outputs.

Other elements that appeared to have been important in delivering the Air Program, but that are not necessarily part of existing systems, were:

- **Working collaboratively to access appropriate expertise**. Both DPE and external interviewees highlighted that the CAS team's approach of working collaboratively has been a valuable approach in adding value to the Air Program. Examples of the sorts of collaborative relationships fostered by the team include:
    - use of artificial intelligence and neural networks to enhance forecasting accuracy

  - research on the interaction between standard air quality parameters, pollen and meteorological conditions
  - bushfire and hazard reduction burn modelling and forecasting.

  This allows the CAS branch to make progress in air quality science, without needing niche expertise within the team itself.

  They're a good group at collaborating – and that's important. Science moves fast and getting those people involved, and especially in the forecasting group, they need to be doing what they're doing to be on top of it

- **A culture of professionalism and hard work among CAS branch team members**. 15 external stakeholders highlighted the team's responsiveness to inquiries, their hard work and their professionalism. They emphasised that this is important from the perspective that the team delivers a service to the community and to key stakeholders and that this service is provided in a timely and responsive manner.

  It's a crucial role and they work hard to get the information out – certainly a very dedicated group (external researcher)

  That team is one of the best teams I have worked with – they're incredibly professional (Non-CAS DPE staff member)

- **Adaptation and response to feedback** – this was most notable in terms of the website design and inquiries through the DPE Enviroline/mailbox that provided suggestions on website issues and improvements.

  There were a lot of problems with academics and NGOs because of problem downloading data, which has all been sorted, and the air quality maps have been improved based on feedback too. They are getting the feedback and they are responding. (Non-CAS DPE staff member)

4.4 Delivery challenges and barriers

As with many programs delivered over the past few years, the Black Summer bushfires in 2019/2020 and the COVID-19 pandemic created a range of challenges for delivery. However, the Black Summer fires, in particular, substantially increased the time and resources the team needed to put into their monitoring, forecasting and communication work. For example, the Black Summer fires led to:

- additional media and public inquiries about the nature of air quality monitoring data and the air quality monitoring network
- deployment of nine emergency monitoring stations and the associated coordination and servicing of these stations
- increased attention on the website upgrade and prioritisation of this task – as noted by one interviewee, the bushfires "pushed us to breaking point where the network fell over with the amount of traffic on it"
- a general raising of expectations with respect to the availability and coverage of air quality monitoring data.

The expectations are very high now. Everyone's carrying their phones and can access it 24 hours a day, so that puts pressure on making sure what's coming out is at a high standard … compared to a few years ago, there's much more pressure. People are aware and they want to know more… (external stakeholder)

In addition to the Black Summer bushfires, other key challenges that the Air Program included:

- **Uncertainty for people employed on temporary contracts**. As people moved on, this then flowed through to higher workloads and pressure among remaining team members.
- Competing priorities in accessing shared computing resources
- Lack of clarity in process, roles and responsibilities in managing IT projects between CAS and DIO
- The technical challenges of working on complex subject matter.

While not challenges to delivery per se, stakeholders also highlighted several opportunities through which delivery could be improved:

- A lack of clear structure with CAS, with priority actions delivered across teams. This created some confusion for external stakeholders. Two interviewees also suggested that the way the Air Program was delivered within the branch (with responsibility for delivery split across teams with no program manager) created uncertainty in priorities among the teams. It also created an environment where team leaders did not have extensive engagement with or a clear 'line of sight' to the program budget.
- The potential to increase the visibility of research, including what is currently in progress and what is planned for the future.

There's just so much going on … it would be nice to have a more structured way to communicate some of the work. Not just to us, but also some of the other people they work with. Because we don't always know who's working together and on what … and so we want to avoid duplicating work and having these three-way conversations (Non-CAS DPE staff member)

5 Program effectiveness – delivering information to where it is needed

5.1 Overview

This section explores the extent to which the program had delivered the right information, to the right people, at the right time. Specifically we address the following key evaluation questions:

- How well were the projects delivered by the program, strategically relevant to end-user needs (NSW government policies, priorities and strategies)? (Section 5.2).
- To what extent was information widely diffused to business, community and susceptible population sub-groups? (Section 5.3).
- Do end-users and communities have confidence in the quality, accessibility and timelines of program services? (Section 5.4).

5.2 Strategic alignment

The broad components of the Air Program are well-aligned with key national and NSW policies and strategies (Table 6), including:

- the National Clean Air Agreement 2015
- the NSW Clean Air Strategy 2021-2025 (brought in after the start of the Air Program and that followed on from the Clean Air for NSW Consultation Paper 2016).

Note that although the Clean Air Strategy has come in after the Air Program, it relied largely on consultation as part of the NSW Clean Air Summit in 2017, which also informed development of the Air Program. Other stakeholder engagement during the design of the Air Program appears to have been limited and/or is not documented. That said, the CAS branch maintains a range of relationships with key stakeholder groups and has engaged them during various components of the program, including:

- consultation with website users/potential users as part of the redesign of air quality website
- ongoing engagement with researchers as part of collaborative research projects
- ongoing engagement with NSW Health on public health management needs and provision of air quality data and forecasts
- ongoing engagement with NSW EPA on user needs on air pollution monitoring, control and reporting
- consultation with key interest groups on – such as Asthma Australia, the Newcastle Community Consultative Committee on the Environment and the Upper Hunter Air Quality Advisory Committee.

Table 6. Alignment between components of the Air Program and key NSW and national policies/strategies.

Component	Rationale (from CCF business case)	Alignment with NSW policies/strategies
NSW Air Quality Monitoring Network (excluding industry-funded networks)	Information on current air pollution in the Sydney and Parramatta CBDs is limited. The expansion of air quality monitoring into the CBDs will allow the NSW Government to better understand air pollution exposure in the places where the most NSW people work, live and play.	Enhancing the NSW air quality monitoring network and data is a proposed government action in the NSW Clean Air Strategy 2021-2030. The NSW Environment Protection Authority (EPA) may require air quality monitoring as part of licences under the Protection of the Environment Operations Act 1997 and Chapter 5A of the Protection of the Environment Operations (General) Regulation 2009. Providing information to local communities on air quality is listed as a priority action in NSW Government's strategic plan NSW 2021. Required to align with the National Environment Protection (Ambient Air Quality) Measure
Rural Air Quality Monitoring Network	At the NSW Clean Air Summit in June 2017, the Minister for the Environment announced a suite of monitoring and research commitments to help the NSW Government and the community better understand air pollution across the state. These included: • New monitoring in the Sydney, Parramatta and Penrith CBDs and roadside monitoring (see above component) • Establishing a new rural air quality monitoring network.	Enhancing the NSW air quality monitoring network and data is a proposed government action in the NSW Clean Air Strategy 2021-2030. Providing information to local communities on air quality is listed as a priority action in NSW Government's strategic plan NSW 2021.
Enhancing Air Quality Forecasting in NSW	To ensure that all NSW Government data and information on air quality is openly and freely available to the community, researchers and decision makers. The Climate and Atmospheric Science (CAS) branch currently provides daily (24-hour) forecasts for Sydney. A recent forecast performance review indicates that CAS has a moderate skill for ozone forecasting for the Sydney region and its capability of forecasting high particle	Aligns to the National Clean Air Agreement, which sets a framework to help governments identify and prioritise actions to address air quality issues that would benefit from national collaboration and deliver health, environmental and economic outcomes for Australians. It seeks to enable this by strengthening existing air quality management arrangements that enable responses to current and emerging air quality priorities, and by assisting development of consistent policies for better knowledge, education and awareness, and partnerships and cooperation across jurisdictions.

Component	Rationale (from CCF business case)	Alignment with NSW policies/strategies
	pollution days is limited. While the skill of the qualitative forecasts is comparable by some measures to other more sophisticated systems, there exists a need to expand and enhance air quality forecasts for NSW. Hence, CAS plans to progressively advance its capability for forecasting air quality within the Greater Metropolitan Region and key regional areas in NSW.	A priority in the NSW Clean Air Strategy 2021-2030 is: Better preparedness for pollution events: improve information and how it is communicated to help reduce health impacts of air pollution on NSW communities, including impacts from bushfires, hazard reduction burns and dust storms. The NSW State Health Plan Towards 2021 sets out Direction 1: Keeping people healthy – help people manage their own health. In line with the NSW Health's responsibilities, the AQFF aims to provide improved forecasting service that people of NSW, especially those who are susceptible to poor air quality, have information needed to take preventative actions to minimise personal health impacts[17]. Providing information to local communities on air quality is listed as a priority action in NSW Government's strategic plan NSW 2021.
Sydney Air Quality Studies	Not discussed in the CCF business case	Aligns to the NSW Clean Air Strategy 2021-2030 approach to improving air quality and protecting communities through actions that will reduce emissions and exposure, commit to clean air across government, and evaluate and improve air quality management. Fundamental to this goal is the requirement to implement federal legislation guidelines on ambient air quality monitoring in NSW (National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM))[18] and to monitor air quality management progress by publishing air quality reports.
Clean Air by Design Projects (Clean Air for NSW CCF Business Case Actions 1, 3 and 4)	Information on current air pollution in the Sydney and Parramatta CBDs is limited. The expansion of air quality monitoring into the CBDs will allow the NSW Government to better understand air pollution exposure in the places where the most NSW people work, live and play. Establishing a baseline air quality monitoring station in rural NSW will provide background air quality data	Aligns to the fourth strategic approach outlined in the National Clean Air Agreement: Better knowledge, education and awareness are essential requirements to inform policy decisions and to help empower communities and individuals to better deal with air pollution. Knowledge, improved through information sharing and research, is critical to plug existing data gaps, identify future trends and help focus efforts in managing air quality, and explore innovative measures to address air pollution. The Agreement's initial work plan also includes a two-year plan for reforms to improve the National Pollutant Inventory.

[17] See Air Quality Forecasting Project Plan (5 year)
[18] See National Environment Protection (Ambient Air Quality) Measure (legislation.gov.au)

Component	Rationale (from CCF business case)	Alignment with NSW policies/strategies
	Enhancing the Air Quality website and data delivery will ensure that all NSW Government data and information on air quality is openly and freely available to the community, researchers and decision makers.	
Emergency incident response monitoring	Not discussed in the CCF business case	A priority in the NSW Clean Air Strategy 2021-2030 is: 'Better preparedness for pollution events: improve information and how it is communicated to help reduce health impacts of air pollution on NSW communities, including impacts from bushfires, hazard reduction burns and dust storms'. Contributes to improved resilience of community and business to climate change, environmental hazards and risks (NSW Climate Change Policy Framework and the DPIE Outcomes and Business Plan)

5.3 Diffusion of information

One of the key outcomes in the Air Program's program logic is that *the community, government and businesses decision-makers have access to the right information, at the right time and at the right scale* (see Section 3.2, Figure 2). **As such, this evaluation asks *to what extent was information widely diffused to business, community and susceptible population sub-groups?*** This includes the appropriateness of the scale of the information. Whether the information was timely and of the appropriate quality, is addressed in Section 5.4.

Several issues are relevant here:

- the distribution and coverage of the NSW air quality monitoring network, including its relationship to the AAQ NEPM requirements (Section 5.3.1)
- stakeholder perceptions of the network (Section 5.3.2)
- communication of air quality information (Section 5.3.3)
- use and engagement with communications, particularly the DPE websites and alerts (Section 5.3.4)

5.3.1 Distribution of the air quality monitoring network

The AAQ NEPM sets the national standard for the minimum level of ambient air quality monitoring that should be done relative to the size of population centres. In NSW, the Australian Bureau of Statistics (ABS) Significant Urban Area (SUA) categorisation are used to assess compliance with the AAQ NEPM's population-based standards. Thus, in line with AAQ NEPM guidance, any SUA (i.e. any city/township) with a population of more than 25,000 should have at least one air quality monitoring station.[19]

A basic analysis (i.e. focusing on population criteria for siting stations alone) suggest that NSW is reasonably well aligned with the requirements of the AAQ NEPM. This has improved during the CCF-funded period of the Air Program.

Based on information in DPE's Air Monitoring Plan 2021-2025[20], in 2021 most of the SUAs with populations of more than 25,000 had some form of air quality monitoring (Table 7). This included NEPM-compliant stations, industry funded stations or indicative air quality monitoring stations (i.e. the updated rural air quality network stations). Key points to note are:

- Six SUAs had some form of monitoring station despite their populations being below the typical threshold for monitoring to be required.
- Five SUAs did not have as many monitoring stations as suggested in the AAQ NEPM.
- Regional monitoring plans produced by DPE explain why some of these SUAs do not have monitoring stations – for example, Nelson Bay and Taree are suggested to have low likely levels of pollution due to their coastal location.

[19] The total number of stations is determined by the NEPM population calculation: Number of stations (rounded up) = population in millions x 1.5 +0.5. Note that the NEPM also indicates that "fewer performance monitoring stations may be needed where it can be demonstrated that pollutant levels are reasonably expected to be consistently lower than the standards mentioned in this Measure" (p. 9).
[20] NSW Air Quality Monitoring Plan 2021-25: Methods for creating plans. 2021. Department of Planning, Industry and Environment.

- There was no explanation in the monitoring plans for why Bowral – Mittagong and Ballina did not have the recommended level of monitoring, though DPE staff clarified that it was because Ballina is close to Lismore and Bowral-Mittagong is close to Bargo.

Importantly, **during the period of the CCF-funding (2017-2022)**(see Table 7 and Table 8):

- **Two SUAs had AAQ NEPM-compliant monitoring stations installed (Morisset and Orange**), bringing them into line with AAQ NEPM requirements.
- **Three other SUAs with populations of more than 25,000 also had monitoring stations installed** for the first time during this period (Coffs Harbour, Port Macquarie and Lismore).

Overall, some form of **air quality monitoring occurs in SUAs that cover 6.1 million people, or 82% of the NSW population**.[21] Notably:

- Since 2017, 281,000 people have coverage where they did not before (a 4% improvement) based on the deployment of 12 stations in areas where there were no stations before (Figure 3; Table 8).
- Outside of Sydney, a further 388,000 people have access to more granular monitoring thanks to additional stations in the Central Coast and Wagga Wagga.
- Within Sydney, five additional CBD and suburban sites have enhanced the resolution of monitoring data for hundreds of thousands of residents and commuters.

Table 7. Significant Urban Areas in NSW and associated number of required air monitoring stations based on the AAQ NEPM population criteria. Data from NSW Air Quality Monitoring Plan 2021-25. Shading: green = # NEPM-compliant stations match or exceeds requirements; light green = # of compliant and/or indicative/industry stations meets or exceeds requirements; red = number of stations based on population is not met; grey = monitoring exists based on factors other than AAQ NEPM population criteria.

NSW air quality monitoring region	Significant urban areas	2016 census population ('000s)	# stations required by population	# NEPM-compliant stations	Industry, research or indicative stations
Greater Sydney	Sydney	4447	8	17	2
Hunter	Newcastle-Maitland	463	2	3	3
	Nelson Bay – Corlette[22]	27	1	0	
	Taree	26	1	0	
	Foster – Tuncurry	20	-	0	
	Singleton	16	-	1	2
	Muswellbrook	12	-	1	1
	Aberdeen	2	-	1	
Central Coast	Central Coast and Morisset-Cooranbong	334	2	2	
	Wollongong	286	1	3	

[21] as per the 2016 census, which puts the NSW population at 7,480,228

[22] The Air Quality Monitoring Plan for the Lower Hunter Region 2021-25 notes that "pollution levels are expected to be quite low" in Nelson Bay, Taree and Forster "as they are coastal areas with minimal local emissions sources". (p.16).

NSW air quality monitoring region	Significant urban areas	2016 census population ('000s)	# stations required by population	# NEPM-compliant stations	Industry, research or indicative stations
Illawarra-Shoalhaven	Nowra – Bomaderry[23]	36	1	0	
North Coast	Coffs Harbour	68	1	0	1
	Gold Coast – Tweed Heads	60 (624)[24]	2	0	1 (in QLD)
	Port Macquarie	45	1	0	1
	Lismore	28	1	0	1
	Ballina	25	1	0	
	Grafton	19	-	0	1
Riverina – Murray	Wagga Wagga	54	1	1	1
	Albury – Wodondga	48 (89)	1	1	
	Griffith	19	-	0	1
New England North West	Tamworth	41	1	1	
	Armidale	23	-	1	
	Gunnedah	8	-	1	
	Narrabri	6	-	1	
Central West and Orana	Orange	39	1	1	
	Dubbo	36	1	0	1
	Bathurst	35	1	1	
South East and Tablelands	Bowral-Mittagong	38	1	0	
	Canberra – Queanbeyan	36 (432)	2	0	3 (in ACT)
	Goulburn	23	-	1	
Far West	Broken Hill	18	-	0	1
	Mildura – Wentworth	6 (50)	1	0	1

[23] The Air Quality Monitoring Plan for the Illawarra Region 2021-25 notes that sampling prior to 2001 revealed no air quality exceedances, but also acknowledges that this did not account for PM2.5 particles and that the population has since increased by approximately 50%.

[24] population in brackets is for that component of the SUA that is outside NSW – the number of required stations is based on the total population size for that SUA

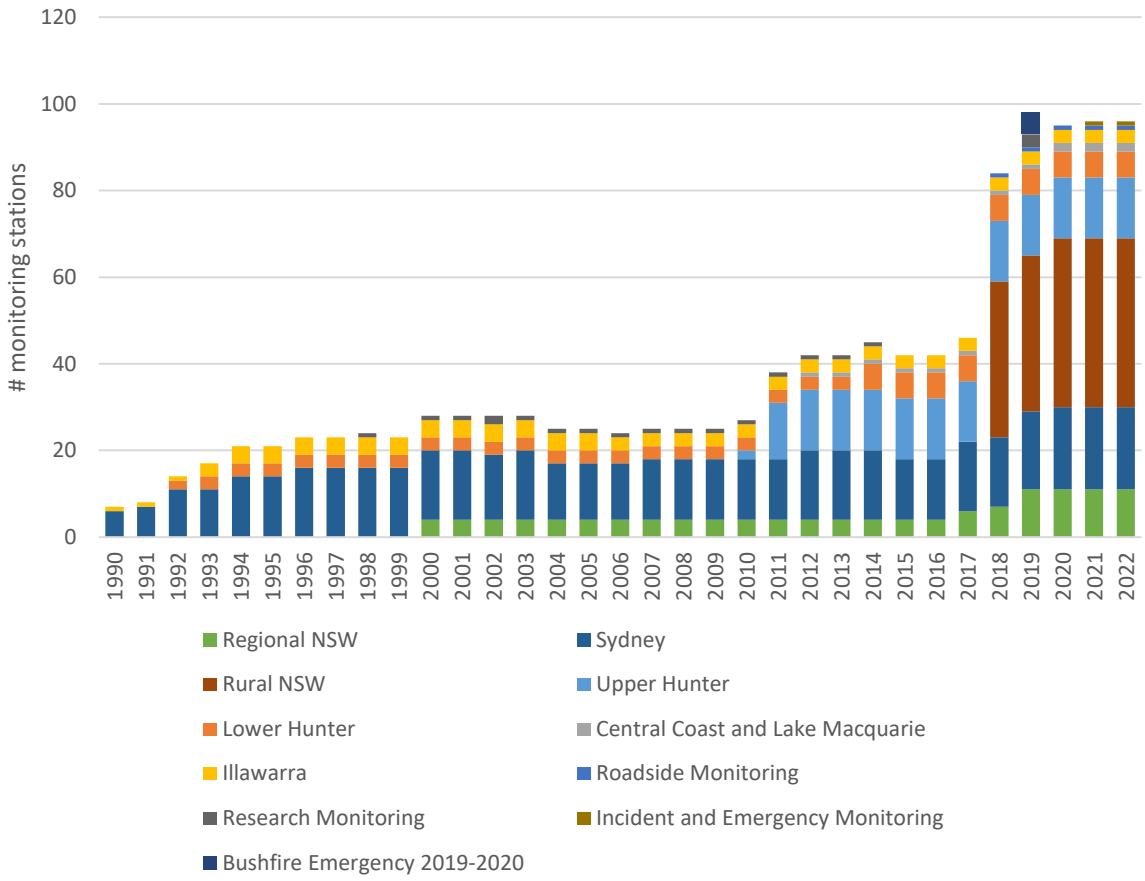

Figure 3. Air quality monitoring sites in NSW since 1990. Data from DPE air quality monitoring station spreadsheet: https://www.environment.nsw.gov.au/topics/air/monitoring-air-quality. Note there were a range of rural stations operated under the Dustwatch network. In 2017/2018 these were upgraded and integration into the broader NSW Air Quality Monitoring Network, which was funded under the Air Program.

Table 8. Additional monitoring sites since commencement of the 2017-2022 Air Program. Note this does not include research or emergency monitoring stations. Data from DPE air quality monitoring station spreadsheet: https://www.environment.nsw.gov.au/topics/air/monitoring-air-quality

Region/ network	Additional sites since 2017 (net)
Sydney	5
Roadside monitoring	1
Regional NSW	8
Rural monitoring network (indicative monitoring stations)	6
Total	**20**

5.3.2 Stakeholder perceptions of coverage

External stakeholders generally considered the coverage of the NSW air quality monitoring network to be reasonable, particularly with the expansion of the network since 2017. Where

stakeholders provided more detail, they typically suggested that Sydney was well-monitored[25] but that most of the gaps are in regional NSW. Overall, however, most specifically acknowledged the coverage of network is balanced against the resources available, with six interviewees (including representatives from interstate) specifically noted that they consider the NSW network to be the best in Australia.

> *But definitely I think the monitoring network gives us quite good access to 'the right information'. (Non-CAS DPE staff member)*

> *NSW has quite good coverage comparing to other states. There are some pretty good data and the coverage is pretty good (External stakeholder)*

Within the CAS branch, a range of interviewees highlighted:

- The CCF-funding provided resources to enable expansion of the network over the last five years. This included new NEPM-compliant monitoring stations but also upgrades to the rural monitoring network stations to allow for PM2.5 measurement, near-real-time data availability and adjustment of the network to provide better coverage to regional population centres (see Section 5.3.1).
- Although funding has allowed the network to expand and improve, there is an associated increase in operation and maintenance costs that is not fully accounted for in the Branch's operating budget.

Although the coverage and information collected by the NSW air quality monitoring network was generally accepted as good, stakeholders also indicated that there is still room for expansion.

> *Monitoring networks are never big enough (DPE Staff Member)*

This is driven, to a large extent, by an increasing increase within the community for monitoring data that is local to them. As noted by another external government stakeholder working in the air quality space:

> *We're hearing, from the community, that they're looking for more air quality monitoring not less. For example, in the Blue Mountains the community has campaigned for having it [the temporary monitor] there permanently and we've heard from other areas that they are after monitoring … We've heard from community that 'our closest monitoring is 200 km away', so they don't have that indication of the air quality in their communities and what is contributing to it. (External government stakeholder)*

Importantly, there was also repeated acknowledgement among key stakeholders that while there is almost an unlimited potential demand for monitoring at finer and finer spatial scales, it is important to focus on where monitoring will deliver the most useful information to inform decision-making.

> *For better or worse there's sometimes a perception of gaps in the network, because everyone likes or wants monitoring in their backyard … so it's a bit of debatable whether more monitoring In certain areas will actually help or …*

[25] the caveat is that DPE staff report getting regular feedback from members of the public wanting monitoring in Sutherland and Northern Beaches

whether it's better to focus on areas where there are actual gaps. (Non-CAS DPE staff member)

This includes more explicit consideration of what sort of monitoring is required in different circumstances and the level of accuracy and reliability required.

5.3.3 Communication and accessibility of the information

Beyond collecting data, the other essential element of making information available for decision-making is about ensuring that the underlying data is appropriately communicated. This is done through a range of mechanisms:

- **The DPE website air quality pages**. Information that is most relevant to general members of the public includes:
    - Summaries of current air quality for different regions (using the air quality categories 'good', 'fair', 'poor', 'very poor', 'extremely poor' (Appendix B)).
    - Forecast air quality for the Sydney region (using the above categories).
    - More detailed station-by-station breakdown of air quality data (excluding rural air quality monitoring network stations), showing hourly averages for ozone, nitrogen dioxide, visibility, carbon monoxide, sulphur dioxide and airborne particles.
    - Separate hourly concentration data for rural air quality monitoring network sites.
    - Maps showing individual station data mapped to station location.
    - Supplementary information to support the air quality data, including guidance on people's level of activity under different air quality conditions, information on the monitoring networks and access to air quality reports and research.
    - A new dedicated air quality website is currently running as a 'first release' in parallel to the existing DPE site. The site has a range of enhancements including integration of the rural air quality monitoring network, adjustments to the reporting regions and improved mapping and mobile functionality.
- **Email and SMS alerts and reports**. This service provides subscribers with a daily SMS or email describing the quality ratings for their selected location, or the forecast for Sydney. The service can also be setup to provide an email/SMS alert only in cases where the air quality category is (or is forecast to be) 'poor' or worse.
- **Data for download**. As part of the website functionality, users can download and stream NSW air quality and meteorological data. This includes:
    - a data download facility for downloading historical data
    - an Application Programming Interface (API) that provides the capability to stream data to a third-party application like a mobile app or search and download historical data
    - a map-based data search and download platform that allows users to explore data from the air quality API and RFS Fires-near-me through the NSW Sharing and Enabling Environmental Data (SEED) Portal.
- **Published reports**. A range of reports and summaries are available to the public, government and other interested stakeholders describing aspects of air quality in NSW. This includes:
    - annual compliance reporting for the AAQ NEPM, which presents and discusses NSW air quality relative to national standards

- annual air quality statements, which summarise the data collected from the Air Quality Monitoring Network
- special air quality statements summarising information about a particular season with significant air pollution events (e.g. the 2019-20 Black Summer bushfires)
- seasonal air quality newsletters for each region (Upper Hunter, Newcastle, Namoi/North-west Slopes)
- monthly DustWatch reports
- insights into individual air pollution episodes – for example, the smoke from hazard reduction burning in September 2017

- **Research papers and other academic outputs**. These outputs are more targeted and focused on particular aspects of the NSW monitoring network, technology, air quality, pollution events or other specific pieces of research and analysis (see summary in Table 9).

Table 9. Summary of CAS publications between 2017 and 2022 based on consolidated list provided to FPC for this evaluation. Publications have been categorised based on the focus of the research/analysis.

Publication focus	Type	Number
Monitoring methods	Technical report/other	3
	Conference paper/ presentation/ poster	20
	Peer reviewed journal article	9
Trends and sources	Technical report/other	1
	Conference paper/ presentation/ poster	6
	Peer reviewed journal article	10
General air quality impacts/ analysis	Peer reviewed journal article	5
	Conference paper/ presentation/ poster	8
Dust impacts	Conference paper/ presentation/ poster	3
	Peer reviewed journal article	1
Bushfire impacts	Technical report/other	2
	Conference paper/ presentation/ poster	4
	Peer reviewed journal article	3
COVID influence on air quality	Technical report/other	1
	Journal	1
Community newsletter		54
Dustwatch report		52
Air pollution event explanation		11
Air quality compliance report		9
Fact sheet/ guide		6
Monitoring plan		6
Total		215

In relation to the above information, it is important to note that **there have been a range of enhancements to how information has been communicated over the course of the 2017-2022 Air Program**. These changes have included:

- **a shift to hourly online reporting** of PM10 & PM2.5 concentration data (away from 24-hour averages) – something noted to be more useful for people in managing their day-to-day activity
- **simplification and standardisation of the air quality categories** to be consistent across Australia (away from the previous air quality index)
- **integration of the rural air quality monitoring network into statewide reporting** (in the new dedicated air quality website)
- **development of the API** for downloading and streaming data
- **other general usability and presentation enhancements** to the website, including mapping and colour coding.

A broad range of external stakeholders interviewed for this evaluation commented positively about the enhancements to the website. This included, for example:

- researchers and other data users who use the data download features of the website, who noted that the functionality has improved

  The availability of the data has improved – so it was previously done on a request basis and now it's all online and the availability has improved in terms of the time periods you can obtain data in. I know there are some different methods of obtaining the data but you can subscribe to a regular download for example but generally we just use a manual go and grab it as needed (Researcher)

- the air quality categories and shift to hourly reporting has generally been seen to be positive (the exception being one stakeholder who highlighted that the hourly data categories are not based on internationally recognised benchmarks)

  It used to be 24-hour averages and then NSW started a rolling hourly information … the hourly stuff is invaluable, particularly if you have a smoky situation outside you want to know when it clear outs and you don't want to wait hours and hours (External government stakeholder)

- there is a general agreement that the information on the website is continually improving and being refined in terms of how it is being presented

  I did go on the website just last week and noticed…. every time I go on, I notice more and more information available in terms of reports being written so I think the level has been increase – information available increasing and their website it quite detailed I think in terms of providing information about how its monitoring and where and what and so on

5.3.4 Use of the DPE website, alert and forecasting services

The mechanisms above provide a means of widely communicating/diffusing information to key stakeholder groups. The proviso is that this communication is largely passive and thus only useful if people are aware of it.

With this in mind, alert services statistics suggests that there are thousands of people that use these data on a daily basis:

- **As of late January 2022, there were 10,972 users of alert services**. Most of these users (6055) had one or more active subscription to a notification (e.g. daily forecasts or alert messaging in cases of poor air quality).
- **The Black Summer bushfires in late 2019 and early 2020 appear to have been the catalyst for a substantial increase in the number of people using the service** (Figure 4). The 5957 new subscribers between October 2019 and March 2020 account for two-thirds (67%) of all the new subscribers during the evaluation period (8848 between July 2017 and January 2022).
- Besides the spike in subscriptions during 2019/2020, the average monthly subscriptions in 2017, 2018 and 2021 were all higher than in previous years (Figure 5). This suggests that there is an **increased interest in and/or awareness of the alert services that is independent of the Black Summer fires.**
- **Most subscriptions were from the Upper Hunter and Sydney** regions (Figure 6). This is despite the Upper Hunter having a much lower population than Sydney.

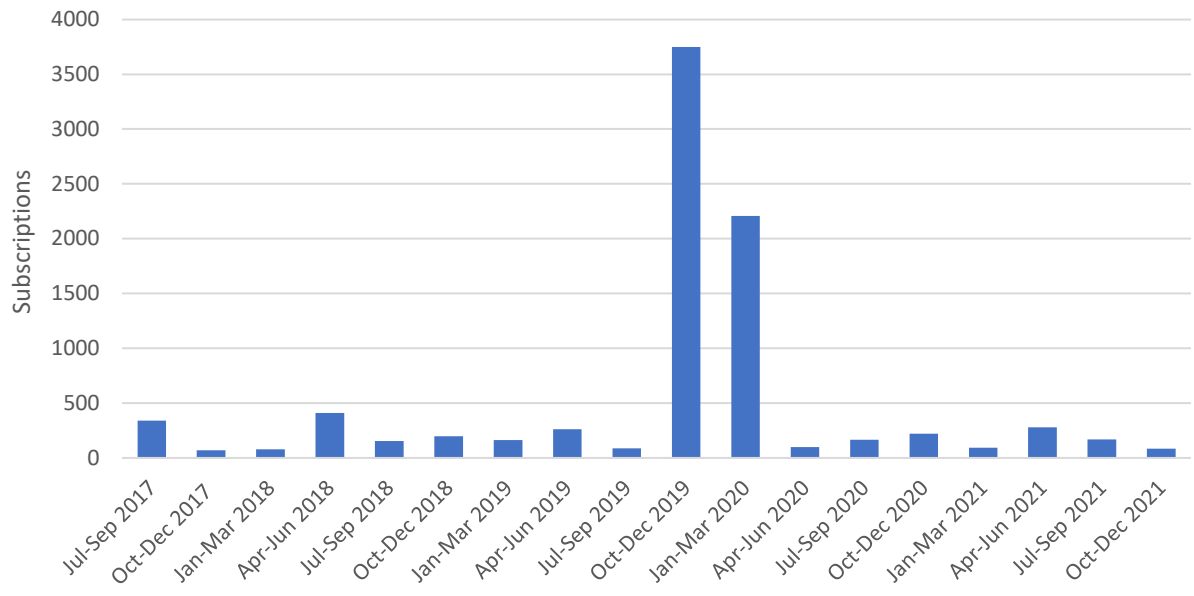

Figure 4. Number of subscriptions to forecasts and air quality alerts between 2017 and 2022.

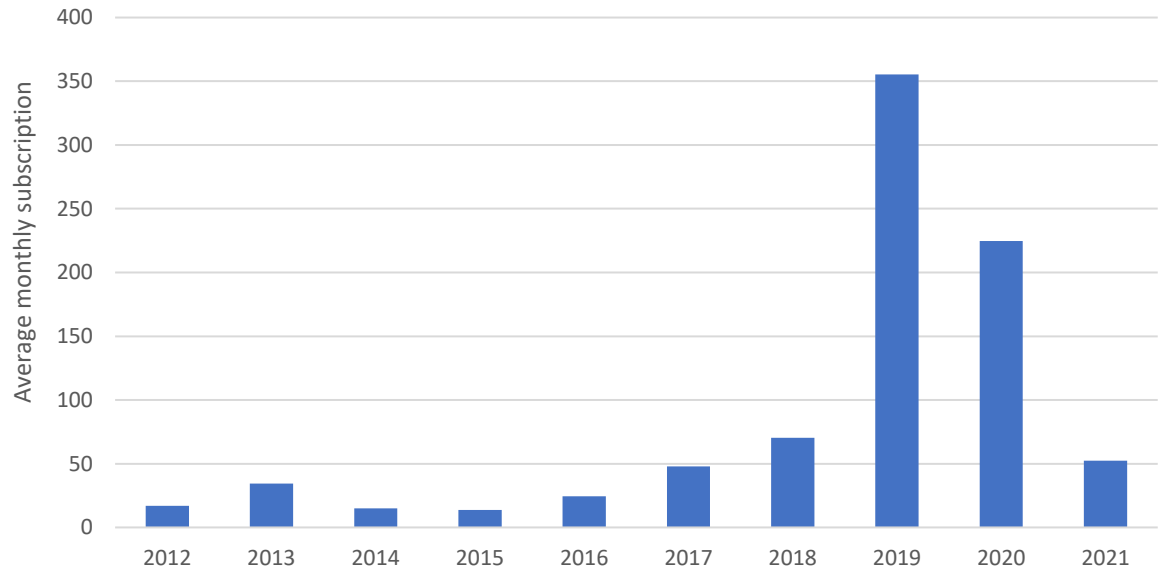

Figure 5. Average monthly subscriptions between 2012 and 2021.

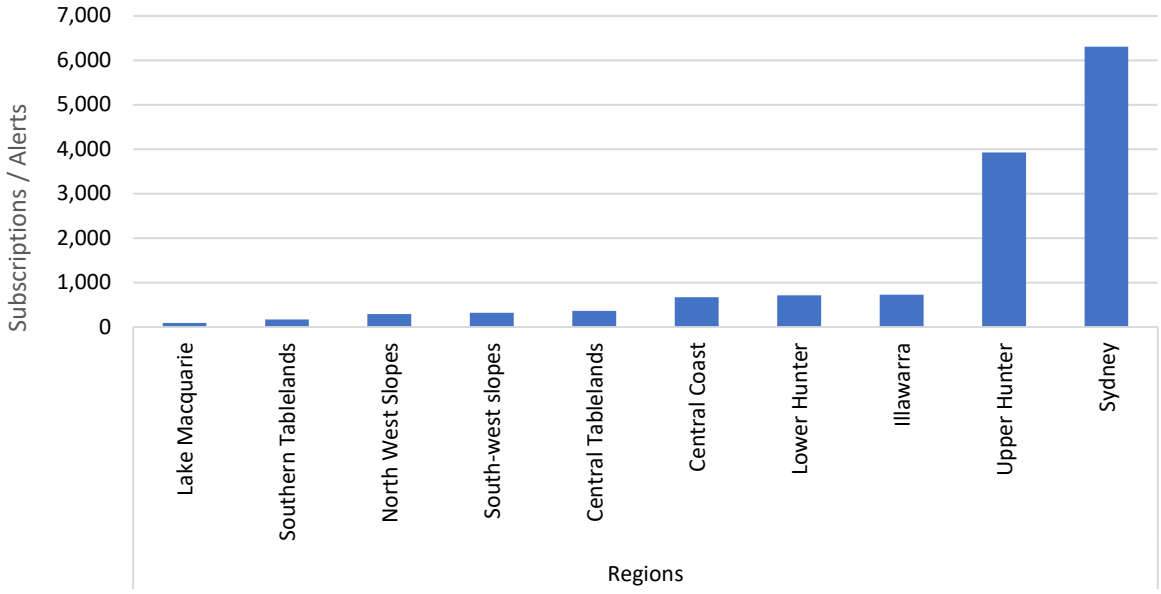

Figure 6. Subscriptions to forecasts and air quality alerts by region.

The DPE air quality website reaches a broader audience than the alert services, though it gets most use during air quality incidents:

- Like the alert services, **there was a large spike in usage during late 2019 and early 2020** (Figure 7). This saw a peak of over 200,000 page views on a single day. Other spikes reflect isolated air quality incidents, such as a Sydney dust storm in late November 2018.
- Between mid-2017 and late January 2022, there was an average of 2957 page views per day.

- During the Black Summer fire period specifically (November 2019 – January 2020), there was an average of 35,844 page views per day.
- Excluding this period, the average has been 1039 page views per day. This is a better reflection of the regular site use during periods when air quality is not a widespread concern.
- This does not account for people who might be receiving information through email/SMS alerts or forecasts.

- The ten most commonly visited pages on the current site account for 95% of all the traffic (Table 10). The 'current air quality' page accounts for 60% of the traffic alone.

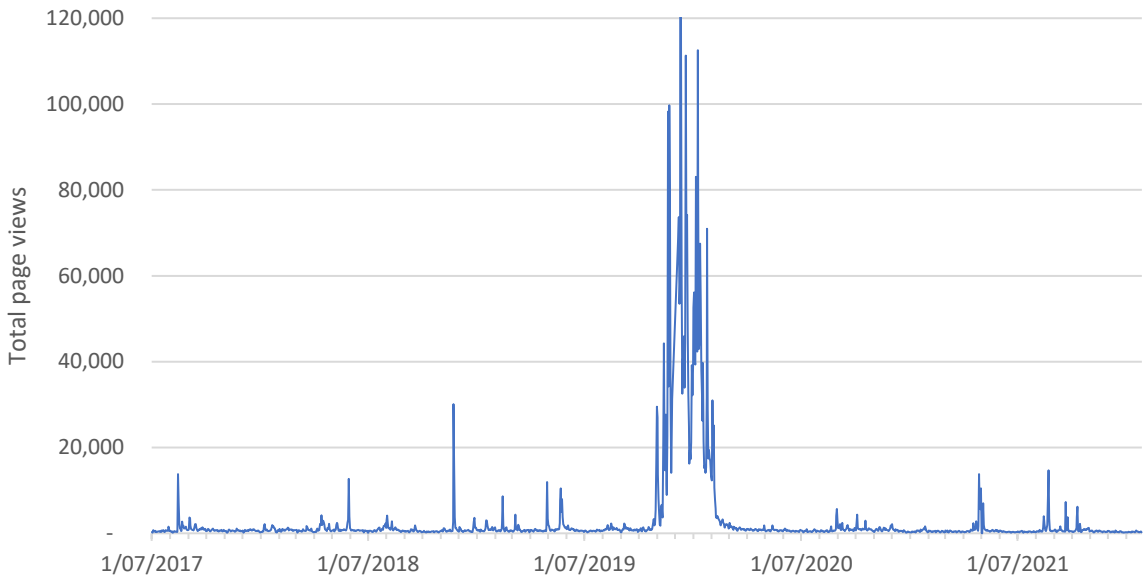

Figure 7. Daily page views for DPE air quality web pages. Note that the x-axis has been trimmed at 120,000, excluding one day when there were over 217,000 views (10 December 2019). Data are combined for the current DPE website, the 'First release' dedicated air quality site and the now-replaced OEH air quality monitoring site.

Table 10. The ten most-commonly pages visited on the DPE air quality website.

Page path	Unique Page Views	% of site traffic
/current-air-quality	1,488,510	60%
/air-quality-concentration-data-updated-hourly	260,652	11%
/sydney-forecast	229,108	9%
/maps/	152,215	6%
/air-quality-alerts	75,970	3%
/current-air-quality/	38,050	2%

Page path	Unique Page Views	% of site traffic
/live-air-quality-data-upper-hunter	20,204	1%
/air-quality-concentration-data-updated-hourly/	30,012	1%
/air-quality-maps/	30,139	1%
/subscribe-to-air-quality-updates	29,104	1%

One last factor to note in terms of access and use of air quality data is the API. This has opened up the opportunity for people to access the data through third-party applications as a complementary mechanism for making information available for extended services and a broader range of users. While several stakeholders pointed to potential issues with these apps – such as the potential for miscommunication or misunderstanding of nuances in the data, they were generally noted to hold substantial potential.

The next most important question is what level of confidence users have in the underlying information. This is discussed in Section 5.4 below.

5.4 End-user confidence

This section explores the question of whether end-users and communities have confidence in the quality, accessibility and timeliness of program services.

Surveyed website users and alert subscribers reported high levels of satisfaction with the information available (Figure 8). Eighty-six per cent (86%) reported being 'satisfied' or 'very satisfied' – notably almost half (46%) of all respondents were 'very satisfied.

The general sentiment in terms of improvements was that there could be (Table 11):

- More detailed information, particularly in alerts/notifications. People were particularly interested in the cause of forecast poor quality conditions, including more information about the contribution of planned burns and bushfires.
- At the same time, there were also some respondents who were interested in simpler and/or clearer messaging. This difference in perspective highlights the difficulty in satisfying the interests and needs of this broad group of end users.
- As noted in Section 5.3.2, another key theme was respondents wanting to see more locally relevant monitoring and forecasting, including forecasting in regional NSW.
- There were also some comments around the accuracy of forecasts – i.e. mis-matches between forecasts and observed conditions. On this point, **a coarse analysis of forecasts and observations over the last five years suggest that the accuracy of forecasts is improving** (Figure 9). This was one of the objectives of the *Enhancing Air Quality Forecasting in NSW* component of the Air Program. This is further supported in feedback about the work being done using artificial intelligence to improve forecasts, with one interviewee noting that early results show a 50% increase in the accuracy of ozone forecasts.

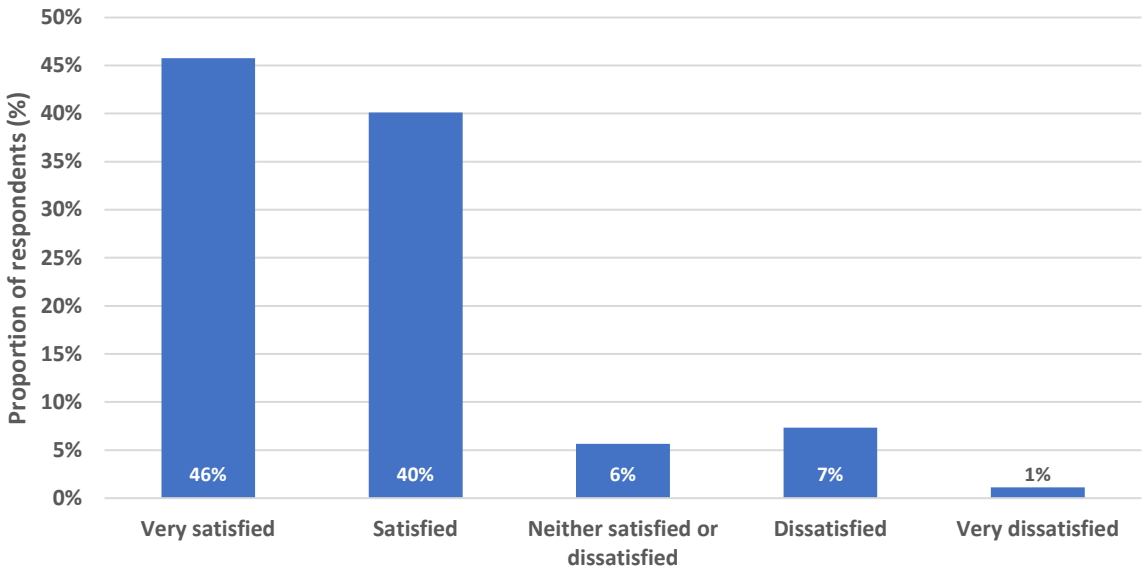

Figure 8. Website survey respondents' level of satisfaction with the 'information available on the website'. n=177

Table 11. Responses to the question 'how could the information available better meet your needs'. n=53

Suggestion	# comments	Indicative quote
Provide more information (e.g. causes of pollution increases)	15	*I mainly would like the notifications to include more information, rather than having to go to the website to find out. E.g., when a warning message arrives, it just says air quality is poor due to PM2.5. It would be really helpful if it said what is causing the increase in particles, particularly if it is smoke or dust or pollen*
More air quality monitoring stations	9	*I wish there was an air quality station on the northern beaches and/or forecasts for this region*
Make information simpler/user friendly	7	*When air pollution exceeds the limits, [it is] very hard to read/understand implications*
Improve the accuracy of forecasts	5	*Also, I wonder how accurate the measures are when after a predictor of "good" quality in an area, there is later an alert for poor or worse levels within the forecast period.*
Include the timing of when air quality is forecast to be poor/change	5	*Forecast timing based on wind direction forecast. This determines the time-of-day approx when it's bad or better.*
Forecasts for outside of Sydney	2	*I would appreciate forecasts for regional areas*
Data about other pollutants (including pollen)	2	*I'd love to know about allergen levels too.*
Information about smoke (fires/planned burns)	2	*Incorporate known burn -offs during summer. On several occasions air quality was forecast as good but was clearly poor.*
Phone app	2	*It would be good to have an Air Quality app with maps of the Sydney regions showing the current air quality. As an asthma sufferer, this would be especially helpful for deciding what areas to avoid, especially when there is bushfire smoke or back burning taking place.*

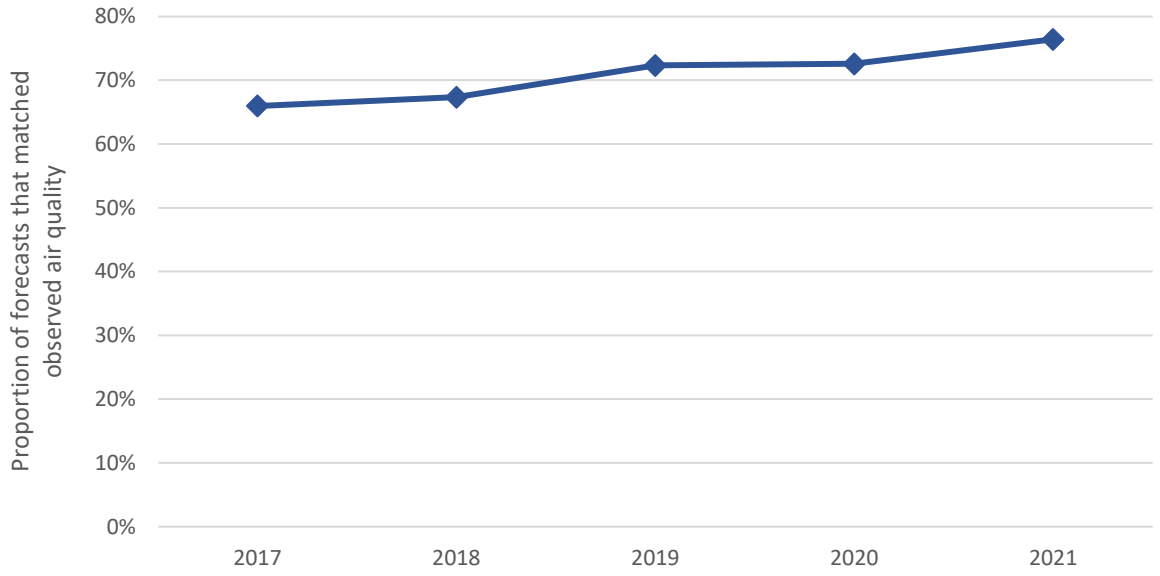

Figure 9. Proportion of Sydney air quality forecasts that have matched with the observed air quality conditions. Based on data supplied by DPE that logs daily forecast and the next day's observed air quality.

In addition to community members, the other key 'end-users' of program services are those that use the detailed datasets and/or reports, such as researchers and government regulators and policy makers. The stakeholders interviewed for this evaluation were overwhelmingly positive about the quality, accessibility and timeliness of the Air Program outputs and services:

- All of the stakeholders who discussed the quality of the data from the DPE website (17) were satisfied with its quality. This included both research and government stakeholders.

> *Without the [DPE] data we wouldn't have access to good quality routinely collected data for the [health and environmental epidemiology] models. They provide an empirical basis to our model and the data represents on the ground real world measurement (Researcher)*

- In addition to the quality of the data, six interviewees (three researchers and three government staff) pointed to the quality of the science and advice being provided by the CAS team.

> *[They have] provided modelling of the current situation versus proposed changes for NOx. It's vital to have that support and modelling … and it's always been good, high-quality advice (External government stakeholder)*

- In terms of accessing data and the other services provided by the CAS branch (e.g. modelling or forecasting), all stakeholders who discussed it (9) considered data and support to be

accessible in a timely manner. Several emphasised, in particular, that the CAS team are highly reliable when it comes to providing timely advice:

> *The service and support they give in our decision making in that science basis and the tech expertise and advice – when put on the spot, they're always making themselves available … I don't know how they go in terms of workloads, but they just get it done (External government stakeholder)*

6 Program effectiveness – improved decisions on environment and public health

6.1 Overview

While Section 5 discusses the data collected and communicated by the Air Program, this Section focuses on how Air Program activities and outputs have flowed onto improved decisions on environment and public health. This includes:

- How outputs have been adopted to improve air pollution management policies and programs (Section 6.2).
- How people have used, or are likely to use, the information to reduce their personal exposure to air pollution (Section 6.3).

6.2 Policy and other outcomes

There are a range of ways in which the Air Program has and is expected to support improved policy, regulatory and operational decisions by government (Table 12). This includes providing information about:

- air quality trends, population exposure and impacts to inform decisions about air quality policies
- air pollution incidents and emergencies to help inform public health advice and management of the situation by emergency services
- air quality forecasts and advice to help plan and manage hazard reduction burns to minimise adverse impacts from smoke
- air quality in particular areas to inform decisions about the regulation or compliance of licenced emitters or planning approvals
- dust and smoke in regional areas as indicators for guiding and improving agricultural practices.

The key caveat to keep in mind in relation to the above is that greater information leads to improved decisions. For a range of cases, as outlined in Table 12, this appears to have happened. It is important to note, however that more and/or better information in and of itself does not invariably lead to better policy outcomes. This was illustrated by one interviewee with respect to wood heaters:

> *Additional information and ongoing monitoring in regional and rural areas and in Sydney [relating to wood smoke] is a good thing. Keeping that currency of an evidence base is a good thing. But the decisions of government - and the lack of action is a decision – has nothing to do with the available evidence base. Put simply, more science (on the impacts of wood heaters) is unlikely to change the policy outcome. (External stakeholder)*

Table 12. Examples of how Air Program activities and outputs are expected to benefit policy and other decisions.

Mechanism	Key features of Air Program activities and outputs	Flow-on outcome(s)
Provide information about air quality trends, population exposure and impacts to inform decisions about air quality policies	**The air quality monitoring network** provides the foundational dataset for tracking ambient air quality in NSW. In its most simple form, **data from the air quality monitoring network allows NSW to report on its air quality** in key documents, such as: • the NSW State of the Environment • AAQ NEPM compliance reporting There then appears to be two further ways the air quality monitoring information flows into policy-decision-making. **1) Through analysis and synthesis done by the CAS branch itself**. The Sydney Air Quality Studies are a key example of this. In particular, they contributed to enhanced understanding of the sources and trends in air pollution and the flow on impacts for communities. *There's so much work that we take out of it for our team … you're talking about the exposure modelling, you're talking about the health impact assessment side of things - that all feeds into policy. (Non-CAS DPE staff member)* **2) Through work done by other stakeholders.** The air quality network and associated data also forms an important input for other researchers, who then use these data in policy relevant research. *We use their data and advocate for various activities and policies concerned with the health consequences of air pollution. [We] have done health studies to identify health risk associated with various air pollution sources and advocated for policies to reduce air pollution, focusing on where the biggest gains can be made in the shortest amount of time. (researcher)* Recent examples include: • research on the public health costs of wood heater emissions in Armidale[26]	It is difficult to directly attribute any particular decision to the information provided through the Air Program. However, **there have been a range of broad scale policy and regulatory changes in recent years that stakeholders indicated air quality monitoring and research have contributed to**. These changes have clear and logical links to the work of the CAS branch. They include: • publication of the NSW Clean Air Strategy, that includes better preparedness for pollution events and improving information and how it is communicated to help reduce health impacts of air pollution on NSW communities, • updating of the Approved Methods for Modelling and Assessing Air Emissions[28] • strengthening of the AAQ NEPM standards (April 2021) One of the other key changes in NSW in recent years has been the **strengthening of regulations around wood heaters**. In 2016 the Protection of the Environment Operations (Clean Air) Regulation 2010 was amended to include minimum standards for the performance of and emissions from domestic wood heaters. Although just prior to the 2017-2022 Air Program beginning, this is indicative of the sorts of broad impacts that the program contributes to. Further changes to these regulations are slated for late 2022, following public consultation. A government stakeholder emphasised the importance of the underlying data and research in decision making: "It means we can defend our policies because they are based on science" (External stakeholder)

[26] Robinson DL et al. The effects on mortality and the associated financial costs of wood heater pollution in a regional Australian city. Med J Aust 2021
[28] https://www.epa.nsw.gov.au/your-environment/air/industrial-emissions/sampling-analysing-air-emissions

Mechanism	Key features of Air Program activities and outputs	Flow-on outcome(s)
	• comparisons between indoor and outdoor air quality during a protracted peat fire in Port Macquarie[27] • honours-level research on the impacts of air quality on photovoltaic solar production • a Commonwealth-level review of fuel quality impacts on emissions	
Providing information about air pollution incidents and emergencies to help inform public health advice and management of the situation by emergency services	The CAS branch operates a range of emergency air quality monitoring stations. These can be deployed at short notice to provide information on air quality impacts from events such as bushfires, industrial fires, dust events etc. **Emergency and special deployments in recent years have included:** • nine stations that were used during the 2019-2020 fires, allowing for monitoring in locations such as Coffs Harbour, Taree, Grafton, Lismore, Cooma, Ulladulla, Batemans Bay and Merimbula • a station at Lismore to monitor air quality impacts from a fire at the Lismore Recycling and Recovery Centre • research monitoring in the Blue Mountains as part of the Blue Mountains and Lithgow Air Watch Project • 3 stations deployed to monitor emissions from an underground fire at Kooragang Island	The information from these mobile monitoring stations, together with the air quality forecasting capabilities (described below), was noted to **help agencies managing these incidents to understand the nature of the air quality impacts** from these events. This allowed them to: • **formulate effective public communications** • **plan or adjust the work of emergency management agencies** to reduce the exposure of their teams or provide further advice to the community on appropriate behaviours. *The fact that there was equipment of that nature and calibre available – we were incredibly grateful for and impress by the response. It allowed us to strongly message around the health impacts and that data was vital in those first few days and in giving answers to the media (external stakeholder)*
Air quality forecasts and advice to help plan and manage hazard reduction burns to minimise adverse impacts from smoke	**The Air Program team regularly provides information to people planning and coordinating hazard reduction burns**. This includes staff from the NSW Rural Fire Service (RFS) and the National Parks and Wildlife Servce (NPWS). Key points here are that: • both RFS and NPWS consult with the Air Program team when planning hazard reduction burns • they seek information about the likely air quality for the planned burn period to understand what the cumulative impact on communities might be	While it is difficult to point to measurable outcomes from the information provided to teams running hazard reduction burns. However, **there was strong feedback that information from the Air Program team**: • **does change decisions about where and when burning occurs** and what communication is done with the public • **informs operations during burns**, including processes such as road closures or signage

[27] Wheeler A et al. Can Public Spaces Effectively Be Used as Cleaner Indoor Air Shelters during Extreme Smoke Events? International Journal of Environmental Research and Public Health 2021. 18: 4085

Mechanism	Key features of Air Program activities and outputs	Flow-on outcome(s)
	• it is also an opportunity to review smoke plume modelling *The air quality monitoring data is very important for the smoke impact for fires and prescribed [hazard reduction] burns. That observation network is really important for us, both in a planning sense and in operations (Agency stakeholder)*	• has **helped to validate and improve smoke plume modelling done by the RFS**. *The team does use smoke modelling to see if hazard reduction burns should go ahead or not depending on plume modelling. [They] seem to pretty well forecast the conditions and type of smoke … so I would say the data is consistently getting us in the ballpark and is valuable to us (Agency stakeholder)*
Information about air quality in particular areas to inform decisions about the regulation or compliance of licenced emitters	Beyond the broad air quality policy decisions noted above, **the Air Program has also been useful for supporting decisions about specific sources of emissions** – such as businesses licenced by the EPA. This might include, for example, providing analyses and comparisons of air quality to understand the emissions from a particular source, or modelling to understand the cumulative exposure to pollution experienced by surrounding communities. In turn, this helps the EPA and planning authorities to make decisions about licence conditions and approvals. This includes planning decisions related to new developments, such as roads – for example if air quality modelling and forecasts suggest a new road tunnel will have unacceptable impacts on surrounding communities, adjustments will be needed to the design of tunnel, such as the engineering of ventilation stacks. *Their input is really valuable in those projects … it seems small but it is real high priority in terms of how it impacts NSW and pollution and air quality (External stakeholder)*	The key example cited by interviewees was the recent licence variation application by the Vales Point coal power plant. In this case, the EPA requested support from the DPE team to model NOx emissions under different scenarios (different licence conditions). **This expert input was noted to be an important part of the EPA decision-making process**.[29] As noted by a key interviewee: *It was quite a big issue … with lots of community input. We have to make sure we're making informed decisions. (External stakeholder)* The resulting decision by the EPA saw emission limits for NOx reduced by as much as 35% compared to previous limits.
Information about dust and smoke in regional areas as indicators for guiding and improving agricultural practices	The original DustWatch network has long been used as a means of monitoring groundcover (and thus the appropriateness of agricultural practices). The rural air quality network is now increasingly being used to monitor and provide feedback to growers about practices such as stubble burning.	Examples include air quality considerations into the management practices of growers – such as the Best Management Practices of rice growers incorporating guidance on not burning stubble under particular meteorological conditions to reduce air quality impacts.

[29] EPL Variation Application – Decision making report. NSW Environment Protection Authority. https://www.epa.nsw.gov.au/-/media/decision-making-report--licence-variation-vales-point-power-station.pdf?la=en&hash=4F971FD02DA0F8166B07F26B0A7E66E4A20EB006

6.3 Behavioural outcomes

In addition to supporting decision-making among government stakeholders, the other key area of behaviour change that the Air Program aims to support is the behaviour of the general public. The assumed underlying logic is that by providing people with information about air quality, they will be able to make better decisions about their behaviours to reduce any impacts from poor air quality. This might include, for example:

- staying inside
- reducing or changing their activities (e.g. minimising exercise).

There is good support from survey data and from interviewees that air quality monitoring data and forecasts are indeed informing people's behaviours in this respect – particularly for those people who are sensitive to the impacts of air pollution:

- **Almost three-quarters (71%) 'often' use it to help make decisions/manage their exposure** (Figure 10). Close to a further quarter (24%) 'sometimes' use it for this purpose. Thus 95% of respondents are regularly using this information to guide their behaviour.
- **Almost all respondents (99%) indicated that the data and alerts are 'important' (they would miss the information if it was not available) or 'very important'** (they would be severely impacted if the information was not available)(Figure 11).

> *I have pretty bad asthma and I signed up for these daily text messages during the horrible smoke haze of black summer (when I was also pregnant and caring for a young toddler) to help me plan whether outdoor activities the next day that would be safe for us … Thanks for providing this service! It is noticed and appreciated and has probably saved me a trip to hospital or two! (Survey respondent)*

> *I have asthma. Anything that helps my asthma management is useful. I check air quality data every evening and use it to plan / limit my activities (Survey respondent).*

Representatives from NSW Health and Asthma Australia confirmed people were using the air quality information in these ways. They noted that the information is particularly useful for people who are sensitive to air quality – but also more generally to members of the public during periods of poor air quality. This is reflected in the website visitation and alert signup data in Section 5.3.3, which shows a baseline of regular users interspersed with periods of much greater use during pollution events. Thus, while the survey results should be interpreted with some caution because they are likely to be biased towards regular users, there is good evidence, overall, that the information is influencing people's behaviour and there is strong demand for it.

> *Especially during pollution event days, we are deliberately putting messages out so that people do shut windows and stay inside and I think people do look out for those messages (External stakeholder).*

Another key stakeholder who had only recently started working in the air quality space reflected on their own behaviour:

I know I have [changed my behaviour]. I used to work past the harbour bridge but I don't do it anymore. There are areas that I know the air quality isn't' as good and so I don't go there anymore … I have stopped going to certain places because of this information (DPE interviewee)

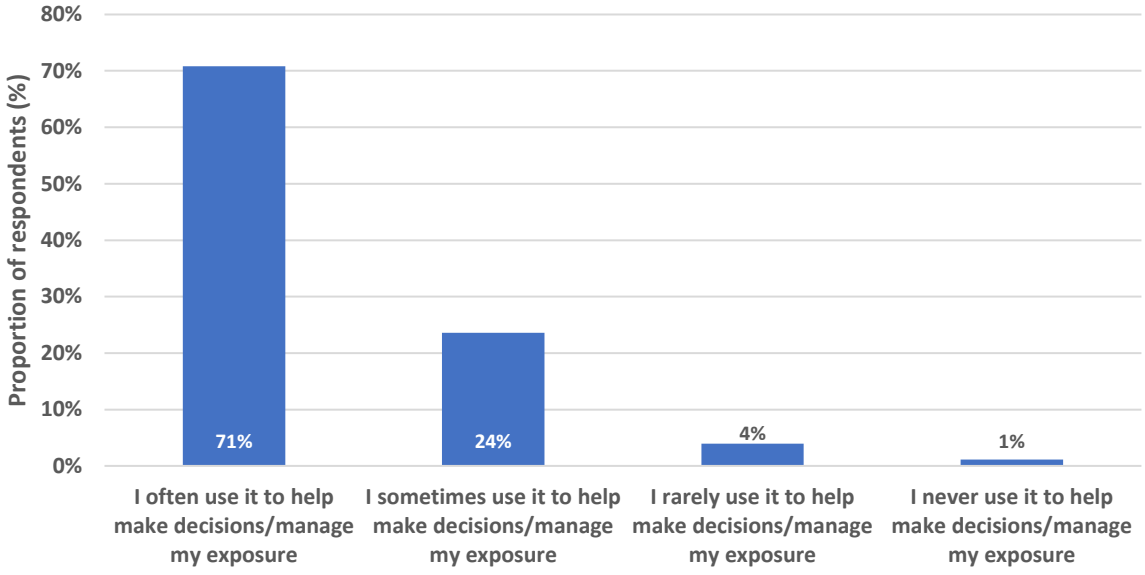

Figure 10. Survey respondents' reported use of air quality monitoring data in guiding their behaviour. n-177.

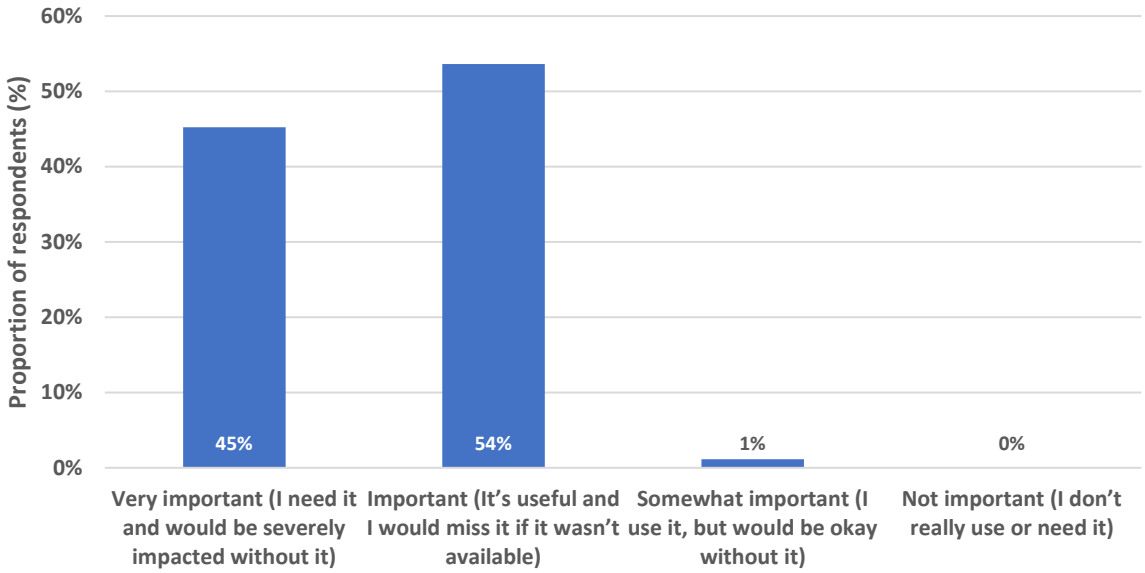

Figure 11. Importance of air quality monitoring data as reported by survey respondents. n=179

7 Other outcomes and value for money

7.1 Other outcomes from the Air Program

In addition to the expected outcomes from that Air Program (information being made available – Section 5; stakeholders acting on that information – Section 6), there were several other outcomes from the CCF-funded components of the program. These include:

- **Improved efficiency of maintenance and service of the air quality network**. DPE staff noted that as well as improving access to data, upgrades to the monitoring station telemetry systems have also provided benefits in terms of maintenance. The new systems allow the team to identify issues more quickly, address some problems remotely and streamline work schedules.
- **Advancing the state of the science with respect to air quality monitoring**. The Sydney Air Quality Studies were the key research component funded through the CCF-funded portion of the Air Program. Its outputs centre on identifying trends and modelling impacts of air pollution on the Sydney metropolitan region. However, a broader range of other research and development work has been done by the CAS branch as part of the implementation of the air quality network and their collaborations with other researchers. In general:
    - It is difficult to disentangle exactly what research has been done and what is in progress. Some stakeholders – including those within DPE – agreed that they had little clarity about this either.
    - Nevertheless, there was good feedback from stakeholders that this work is helping to drive forward the science of air quality monitoring and forecasting in Australia with other states looking to NSW to play a leading role in this space.
    - The key area of work that people repeatedly mentioned was exploring the potential for low-cost sensors to augment or supplement the monitoring network and provide more granular air quality data.
- **Contributions to research and teaching.** One of the primary benefits of making the air quality data available to researchers is to enable external research, analysis and scientific progress. This is discussed in Section 6.2. Importantly, however, the data download facility is also being used by academics to teach data acquisition and analysis skills. Two researchers noted that they use the DPE air quality website as a key tool in their undergraduate science courses, getting students to download, analyse and report on air quality monitoring data.

7.2 Value for money

A key challenge for this evaluation is the overlap between funding provided by the CCF and program activities supported by other funding sources. On top of this, there was limited program documentation available about project-level budgets and expenditure. What data that was available is outlined in Table 13. This shows:

- **The budget for these components of the Air Program adds to $22.5 million over five years. This is around $10 million more than suggested in other program documentation** that puts the CCF contribution at $12.7 million. The reason for this is unclear as the supplied documentation does appear to already account for other funding sources (Table 14). We

suspect this relates to how data has been extracted and reported on, though note (see below) that the program has had some cost-overruns.

- **Only high level information was supplied on salaries and operating expenses for the key components of the Air Program** (Table 13).
- Overall, **around two-thirds (68%) of the costs of the Air Program went to staff salaries**.
- DPE staff indicated that the other key component of the air program, emergency incident monitoring, is not directly funded through the CCF allocation. Instead, it is supported through contingency funds within the statewide monitoring network and relies on leveraging staff time/resources from other parts of the branch – i.e. it does not appear to have an identified budget.
- The only other insight on budget and expenditure comes from excepts from internal departmental summary reports (December 2021).[30] This points to **a substantial overrun in the program budget.** The report notes "The CCF funding ($4.8M)[31] was insufficient to cover the required capital upgrade. The shortfall of $1.8M … was secured from the EES LT, via the EES Budget and Finance Subcommittee. Effectively increasing the program's budget to match the full year forecast of $6.6M". Based on interviewees with DPE staff, this appears to be driven by:
    - the EWADD project requirements ultimately being larger/broader than initially scoped (i.e. requiring a more substantial back-end upgrade)
    - quotes for upgrades being larger than originally budgeted for.
- The lack of clarity and inconsistencies in budgets and expenditure reinforce an earlier observation about the Air Program lacking the sort of program management documentation that might normally be expected from a standalone program.

Table 13. Summary of budgets for key components of the 2017-2022 Air Program. Data from *Copy of Air Program Budgets for Evaluation 15.2.2022.xlsx*.

Component	Budget ($)						Salary %
	2017-18	2018-19	2019-20	2020-2021	2021-22	Total	
Statewide air quality monitoring[32]	1,022,343	1,084,368	1,120,887	1,163,411	1,207,423	**5,598,432**	74%
Rural air quality monitoring	576,258	589,293	484,198	493,241		**2,142,989**	66%
Enhanced air quality forecasting	528,393	536,920	653,992	503,404	498,503	**2,721,212**	79%
Sydney Air Quality Studies	683,610	722,668	714,379	566,792	528,315	**3,215,764**	82%
Clean Air By Design	3,034,159	2,297,505	2,199,116	1,314,253		**8,845,033**	56%
Total						**22,523,429**	68%

[30] *BCS Oct_Dec 2021 Program Status Reports FINAL.docx*
[31] The report also notes that this $4.8 million includes an additional $0.8 million secured from the CCF. The original budget ($4 million) thus corresponds with the 2020-2021 column in Table 13.
[32] Excluding industry funded networks

Table 14. Other funding sources for the statewide air quality monitoring network (excluding industry networks). For period 2017-2022. Data from *Copy of Air Program Budgets for Evaluation 15.2.2022.xlsx*.

Other funding for statewide air quality monitoring (excluding industry funded network)	Amount (%)
Treasury-tied funding	$2,938,862 (30%)
WELE Funding	$1,400,504 (14%)
CCF	$5,598,432 (56%)

The inconsistencies in budgets and the lack of transparency in expenditure make it difficult to assess the value for money of the program. For example, it is not possible to identify what proportion of funding is required for ongoing operation of the network versus investment in new infrastructure, research projects or other one-off initiatives. However, some coarse comparisons and points can be made:

- The scale of the harm caused by air pollution is significant. The draft second report of the Sydney Air Quality Studies estimates the health impacts of just PM2.5 air pollution in Sydney to be in the order of $4-5 billion annually.[33] This is broadly commensurate with other studies of the impacts of air quality as outlined in Table 15.
- When costs are so substantial, even marginal improvements – for example because people are better informed through air quality monitoring or improvements because of tightened standards – can have substantial flow-on benefits. For example, even a 5% reduction in these exposure impacts equates to around $200-250 million annually in Sydney: more than 40 times the annual budget of the Air Program above.
- There is a strong rationale for continued investment in this space. The key question here is whether the benefits from the Air Program – i.e. an informed public, reliable data for informing policy etc. – can be delivered at a sustainable or reduced cost. DPE staff and excerpts from internal reports suggest the current level of funding is not sufficient to continue to deliver the CAS branch services / Air Program as it is currently structured - while the monitoring infrastructure has expanded and improved as discussed elsewhere in this report, it is not clear whether there are sufficient resources to continue to maintain the network at this size/scale. In addition to obtaining increased resources, there are thus important opportunities to:
    - consider in more detailed where costs are being incurred and what their overall contribution is to the outcomes of the Branch/Program
    - in the context of the continued demand for an expanded network, continue to pursue cost-effective technology, such as low- (or lower-) cost, fit-for-purpose monitoring stations.

[33] Sydney Air Quality Study – Program Report: Part 2 – Health Impact Assessment. Department of Planning and Environment. Draft v0.9.

Table 15. Examples of the scale of the costs of air pollution on human health.

Pollutant	Estimated annual costs	Reference
Allergens	$1.2 billion on treatment $1.1 billion in lost earnings (Australia-wide)	The Economic Impact of Allergic Disease. 2007. Access Economics
Ambient Particle Pollution	Between $1 and 8.4 billion in NSW	Air Pollution Economics – Health Costs of Air Pollution in the Greater Sydney Metropolitan Region. 2005. Department of Environment and Conservation
Wood heater smoke particles	$33 million in Armidale (population 24,504) [~$6 billion if scaled up to the population of Sydney, acknowledging wood smoke is generally worse in Armidale]	Robinson et al. 2021. The effects on mortality and the associated financial costs of wood heater pollution in a regional Australian city. Medical Journal of Australia 215.

8 Key findings and recommendations

8.1 Key findings and insights

8.1.1 Achievements

Through delivering the Air Program, the CAS branch team has made a broad range of improvements to the NSW air quality monitoring network and the science underpinning air quality monitoring and forecasting. This has contributed to enhanced understanding of air quality among the community and key stakeholders. In turn, this has helped to inform air quality policies, air quality management and individual behaviours that reduce exposure to pollution.

Some of the main achievements have been:

- **The air quality monitoring network in NSW has been substantially expanded**. There are 20 new monitoring sites compared to 2016, including eight sites in major regional NSW towns and five in Sydney. Excluding improvements in Sydney, 9% of the NSW population has more granular air quality information. 4% of the NSW population now has access to air quality monitoring in regional townships where there was none previously.
- **The existing DustWatch network has been upgraded and integrated into the broader statewide monitoring network.** There are now 33 sites across rural NSW.[34] Stations are also now capable of monitoring PM2.5 particles and providing data in near-real-time.
- **There have been substantial upgrades and improvements to the air quality website and associated communications.** This includes a new, dedicated NSW air quality site. There has been good feedback that the website is more user-friendly and accessible than it was previously. Other key changes include the use of clearly (and nationally consistent) colour-coded air quality conditions and air quality concentration data has been shifted to be displayed in hourly averages.
- **The accuracy of air quality forecasting is** improving and the underlying air quality modelling approach has been updated in line with the most advanced European and US models.
- **Emergency incident monitoring stations have been used extensively through the Air Program,** for example, nine stations were deployed during the Black Summer bushfires to help monitor air quality and support agencies managing the fires.
- **The Sydney Air Quality Studies** have delivered a comprehensive assessment of the trends and sources of pollution in the Sydney metropolitan region. This analysis has underpinned the recently released NSW Clean Air Strategy 2021-2030 and is soon to be complemented with a second analysis outlining the health impacts of air pollution.

There is good evidence that the ongoing operation of the Air Program, combined with the expansion and enhancements noted above, is flowing through to on-ground impacts. In particular:

- **1000s of people use the website and/or the forecasting and alert services on a daily basis.** During the Black Summer bushfires in late 2019 and early 2020, daily website use was around 35 times the average. New subscribers to alerts during this period account for two-thirds (67%) of all the subscriptions over the last five years.
- **86% of surveyed website users and alert subscribers are satisfied with the information available**
    - 95% regularly use it to help make decisions/manage their exposure

[34] plus six interstate that act as nearby/early warning stations

    - 99% indicated that the data and alerts are important.
- All of the interviewees who discussed the quality of the data from the DPE website (17) were satisfied with its quality.

In terms of broader decisions relating to air quality, the Air Program appears to be delivering information about:

- Air quality trends, population exposure and impacts to inform decisions about air quality policies – this includes the NSW 2021-2030 Clean Air Strategy and tightening of air quality standards at the national-level.
- Air pollution incidents and emergencies to help inform public health advice and management of the situation by emergency services.
- Air quality forecasts and advice to help plan and manage hazard reduction burns to minimise adverse impacts from smoke.
- Air quality in particular areas to inform decisions about the regulation or compliance of licenced emitters or planning approvals, a key example being supporting decision-making about strengthening the emission standards for the Vales Point power plant.
- Dust and smoke in regional areas as indicators for guiding and improving agricultural practices.

8.1.2 Delivery challenges and enablers

While there have been a broad range of improvements and outputs created under the Air Program, not all of the program components appear to have been delivered as planned. One of the key issues here appears to be a lack of a clear program plan and deliverables. **Acknowledging that the program still has three months to run, key areas that do not yet appear to have been completed are**:

- Enhanced air quality forecasting. Although DPE staff noted there has been extensive work on and improvements to the underlying modelling frameworks, **the objective of delivering forecasts for outside the Sydney area has not yet been achieved** (is still under development).
- Although the EWADD project has made substantial improvements to the website interface as well as progressing some of the underlying infrastructure**, the project is still being delivered and has required substantial additional resources.**

Some of the general challenges contributing to these issues include:

- delays created by the Black Summer bushfires in 2019/2020, which drew resources away from projects into substantially increased demand for monitoring, forecasting and communication work.
- a general raising of expectations with respect to the availability and coverage of air quality monitoring data.
- uncertainty for people employed on temporary contracts.
- limited computing resources required for modelling and forecasting work
- lack of clarity in process, roles and responsibilities in managing IT projects between CAS and DIO
- the underlying technical challenges of working on complex subject matter.

These challenges aside, the Air Program benefited from several structures and approaches that supported delivery and are important to recognise for future work in this space. Key enablers were:

- the Air Program has a well-established Quality Management System, which include standard operating procedures and processes that are regularly reviewed and updated in line with machinery of government changes over several decades
- collaboration has been important in accessing access appropriate expertise.
- there is a strong culture of professionalism and hard work among CAS branch team members
- there is a good level of openness to adapting and responding to feedback, particularly with respect to the website and other key communications.

8.1.3 Other observations and lessons

Several key themes emerge from different parts of this evaluation:

- The Air Program team is faced with **the underlying challenge of providing an increasingly broad and diverse monitoring network while being constrained to a set (or potentially even reduced) operating budget**. It is important to note, however, that there are multiple purposes to the monitoring network and these are not always clearly articulated or separated. For example, helping community members make decisions about their activities on a day-to-day basis is different – and can be fulfilled by a different type of network – to measuring long-term trends or exceedances in air quality variables.
- On a closely related point, much of the documentation related to the Air Program clearly articulates the high-level outcomes that the program and the CAS branch are working towards. This includes, for example, improvements in air quality and the resilience of NSW communities. One of the issues here, however, is that **there is often a large gap between the particular program/project activities and those high-level outcomes**. This makes it difficult to understand what a particular project or initiative is realistically aiming to achieve. Many key documents, for example, lacked clearly defined objectives, including the CCF business case. This risks projects being set up without a clear picture of what they are actually trying to achieve within the program timeframe.
- The Air Program has been an intertwined mix of business-as-usual and one-off initiatives, delivered across multiple teams within the CAS branch. **There is a lack of program-level documentation**. This has made it difficult to systematically evaluate the program but is also likely to have impacted how the program itself was delivered. For example, key interviewees indicated that delivering initiatives across CAS teams contributed to issues around prioritisation of tasks and budget management.
- Much of the work of the Air Program is about generating high quality information that people then go on to use to inform decision-making. **Improvements to how information is communicated through the website was an important achievement for this program**. For example, user surveys for this evaluation confirm the value of the services for regular users. However, ensuring information is well-communicated and effectively understood remains an ongoing risk and opportunity for the program – including among government stakeholders and the general public.

8.2 Recommendations

Based on the key findings above and the more detailed results in the remainder of the report, we recommend:

1. As DPE continues to manage and refine the air quality monitoring network, **it should clarify what the different goals of the network are and how they might be served by different types of station and approaches to monitoring**. While the air monitoring plans go some way towards this, they would benefit from clearer articulation of what information the network needs to produce and, in turn, what outcomes it is hoping to achieve. At present there is general information on fulfilling AAQ NEPM requirements and that "monitoring is for the protection of public health", but more detail on exactly what questions are being asked and by whom would help in making decisions about the location, accuracy and reliability of monitoring stations and associated work. As NSW's network expands beyond the strict requirements of the AAQ NEPM, having this clarity will become more important
2. In addressing Recommendation 1, **there would be value in developing a more detailed theory of change for stakeholders who are expected to use the outputs of the Air Program and monitoring network**. The current Air Program logic clearly articulates the high-level outcomes it is working towards. It would benefit, however, from having more detail about the shorter- and medium-term outcomes. This includes articulating the different audiences for the information and exactly how they might use it. This process may also be useful in developing a set of key indicators for helping to track performance of the Program/Branch, such as targets around engagement with program outputs or proportion of the population with access to appropriate monitoring information and forecasts.
3. **DPE should consider strengthening its approach to communicating with end-users**. Producing information is a key part of the work of the branch but there is further opportunity to make sure this information is distributed to and understood by those who might need it.
    a. This may need more focus on knowledge and awareness raising as well as ensuring outputs are fit-for-purpose.
    b. The above theory of change/ logic is one step, but there may be value in developing a complementary communication plan or strategy that clearly identifies stakeholders and how they can be engaged.
    c. This includes identifying different user groups within the general community, as well as potential users within government. For example, planners and local government representatives were two key groups that were not suggested or engaged for this evaluation, but that might be important target audiences.
    d. Part of this would be developing a proactive process to make sure the needs of these stakeholders are being met, such as regular surveys or similar. To avoid duplication, this might be done in collaboration with the EPA.
4. **Future programs and tranches of work that use external funding should be designed and managed more transparently**. This includes developing a program plan with clear objectives, timelines, budgets and governance structures. DPE may consider identifying a central responsible person for managing the program, rather than coordination happening across teams via the branch director. This should help in managing budgets, timelines and risks.

5. **To help identify objectives in future projects, there may be value in identifying specific underlying problems**. This has been done to some extent in the current program, though the problems are articulated at a very high level – i.e. that air pollution causes impacts and that a lack of information about air quality is a risk for decision-making. More specific questions and problem statements may help in developing more tightly scoped and implemented initiatives – for example, a problem might be 'the lack of air quality monitoring data in X region that is preventing people from making informed decisions'.
6. **DPE should consider developing a research plan/strategy for the CAS branch**. Although the work of the team appears to be far-reaching, it is not clear what is being worked on and if and how it might be relevant to policy and other decision-makers. A research plan that is designed to explicitly identify and address the needs and interests of policy makers is more likely to lead to work that will support effective decision-making in this space.
7. **DPE should consider developing a range of more detailed reports on program expenditure, including how much staff time is allocated to different activities.** This would be useful in assessing where resources are flowing and what the relative cost-effectiveness is of different activities within the branch. There are likely to be some activities that are unable to be scaled back (e.g. calibration or maintenance). However, there may be others, such as the production of standardised reports, that warrant closer investigation to understand the value (and use) of these outputs relative to the time invested. This could ultimately help the branch set clear priorities and direct resources to the most cost-effective activities.

9 Appendix A – evaluation framework from Air Program evaluation plan

The evaluation framework from the Air Program Evaluation Plan is reproduced in Table 16 below, outlining the key evaluation questions and the data sources DPE suggested may be useful for the evaluation. To this, we have added additional comments about what we considered would be important for the evaluation as it was originally scoped.

Table 16. Evaluation framework for Air Program. Columns 1-4 are sourced from the Air Program evaluation plan (DPE 2021). Additional comments and suggestions for this evaluation by FPC have been added into the last column.

Key evaluation questions and sub-questions	Performance metrics *(broadly defined, specific metrics yet to be refined)*	Existing data sources *(collected as part of BAU)*	New data *(data specifically collected for the purposes of this evaluation)*	FPC comment
KEQ 1: How has the design of the program supported efficient delivery?				
1.1 What worked well?	**Delivery efficiency** - % of projects completed or program milestones reached within planned/agreed timeframe and budget Evidence that end-users requested air quality data and information services (members of public, government agencies, businesses, and special interest groups/organisations)	**Program records** - outputs delivered - milestones achieved - project governance documents - meetings/ decision logs - budget trackers - risk management registers - change logs/issues tackled - post-implementation reviews QMS processes – NATA assessment, audits, QMS upgrade, process reviews/improvements	**Survey results** - program staff - program partners - customers - awards, nominations, mentions Program teams to design survey/questionnaire, determine appropriate points of execution, collect and collate responses in collaboration with Social Research Team	Focus here is likely to be on the subjective feedback from key stakeholders about 'what worked'. This questions also needs to simply describe how the project was delivered, including key outputs, milestones, etc.
1. 2 What were the barriers to efficient delivery, and what improved success?	**Measures for improved efficiency and success** - % of projects where project design was enabling scientific rigor, stakeholder engagement and partnership - Evidence that the interested parties worked collaboratively to design projects, and identify and resolve delivery issues - Evidence that adaptive measures/actions were undertaken to overcome delivery barriers, e.g. changing service needs or budgeting constraints - Evidence that air quality queries from Environment Line and Air Quality Information and web feedback mailboxes were responded to within agreed timeframes	- All above - Queries from Environment Line, Air Quality Information and web feedback mailboxes and response records	- As above	As above, the focus here is likely to be on the feedback from key stakeholders about what the challenges were, etc. This feedback would be paired with any other documented challenges (e.g. milestone reports etc.) and mitigation/ adaptation measures. Air Quality mailbox queries etc are likely to be dealt with in 1.1.
KEQ 2: To what extent does the program deliver the right information to the right people, and at the right time?				

Key evaluation questions and sub-questions	Performance metrics *(broadly defined, specific metrics yet to be refined)*	Existing data sources *(collected as part of BAU)*	New data *(data specifically collected for the purposes of this evaluation)*	FPC comment
2.1 How well were the projects delivered by the program, strategically relevant to end-user needs (NSW government policies, priorities and strategies)?	**Relevance** - Evidence that program priority workstreams/initiatives were developed to implement key aspects of various strategies (NSW Government/EPA/other) - Evidence that program end-users/stakeholders were adequately engaged in program/projects design, delivery and review phases Evidence that projects aligned with funding priorities, new partnerships, collaborations that emerged	**Program records and corporate/other strategies** - 2020–21 EES Group Corporate Plan - DPIE Outcomes & Business Plan - EES Knowledge Strategy - Legislation: AAQ NEPM - NSW Clean Air Strategy - National Clean Air Agreement - CCF Draft Strategic Plan 2017-22 - Funding models for the Air Program	**Collation** of information from the relevant literature domain Independent consultant to evaluate working with program team	We will likely develop a table that explores alignment between the program components and relevant strategies. This would be paired with stakeholder feedback about alignment and involvement in the design process.
2.2 To what extent was information widely diffused to business, community and susceptible population sub-groups?	**Equity** - % of total NSW population with access to locally representative air quality services including monitoring data and air quality forecasting - % of regional/population centres with access to air quality monitoring and forecasting services, where population > 100,000)	- NSW Air Quality Monitoring Plan - geospatially relevant data, as accessible from public facing platforms (e.g. website, database) - geospatial layer of ABS population data - forecast deliveries by region - alerts issued (by region) from internal database - regional reports delivered	**Geospatial analysis** - population with access to services, split by type/scope of services (e.g. monitoring, alerts, forecasts, research) - Assess supplementary services, e.g. short-term bushfire monitoring - Assess sub-population groups' and regional demand/ requests for services Program teams (AR, QSR, AQM) to undertake	Will require reliance on DPE program team to do geospatial analysis. This will be complemented with subjective perceptions and interpretation of how widely diffused information was. Note that availability of appropriate data is not the same as diffusion/ communication to those who have a need for it (particularly, for example to susceptible sub-groups). Will also need to explore communication plans and approaches here.

Key evaluation questions and sub-questions	Performance metrics *(broadly defined, specific metrics yet to be refined)*	Existing data sources *(collected as part of BAU)*	New data *(data specifically collected for the purposes of this evaluation)*	FPC comment
2.3 Do end-users and communities have confidence in the quality, accessibility and timelines of program services?	**Effectiveness** - Statistics (Google Analytics) that show user visits to air quality website - Evidence that non-web based data/information requests were received from a wide range of end-users (e.g. technical users, Councils, general) - Number of subscribers to air quality alerts and forecasts in particular during pollution incidents (email/SMS) - Evidence (e.g. survey results) that engagements were perceived satisfactory or better with the research stakeholders/partners/end-users of foundational data - Evidence of scholarly publications arising from research partnerships and collaborations and use of such publications	- Data analytics (webpages, data download facility, API, SEED portal/other) - User feedbacks (via Air Quality Information and web feedback mailboxes, Environmental Line) - Data services/data sharing (e.g. SoE, NATAG, enHealth, poor air quality forecast notifications) - Database for subscribers - CAS publication records	- **Social research** on user needs, to understand opportunities/ barriers to, access and uptake of services (e.g. forecasts), including sensitive user groups, peak bodies (e.g. Asthma Australia) - "Community Insights" or other organisational surveys Independent consultant to work with Social Research team and Atmospheric Research team	Google analytics may be more useful for 2.2. This question will best be addressed using direct feedback from target groups.
KEQ 3: To what extent has the program achieved improved decisions on environment and public health?				

3.1 To what extent have the program outputs been adopted to improve air pollution management policies and programs?	**Effectiveness**
	- Evidence that program data, information, research and advisory services are used to improve air pollution management policies and programs, e.g.
	  ○ use of program outputs in formulation of pollution reduction scenarios/programs/strategies
	  ○ use of program outputs in AAQ NEPM review
	  ○ use of program outputs in environmental and public health reporting
		- Relevant policies, priorities, publications by NSW agencies/other relevant sectors that inform decision-making (e.g. EISs, RISs, SoE Reports, CBAs, HRB planning decisions, policy/ regulation/other publications/programs)
		- Reports, media, popular articles, publications and citations arising
		- NSW Air Quality Monitoring Network data, air quality forecasts and observations
			- **Desktop literature review and analysis**, to determine if and how information provided by the program has been used (monitoring data, forecasts, specific analyses)
			- Stakeholder survey
			- Literature review
			Independent consultant to work with program team
				While a desktop review may be useful in confirming use of program outputs, interviews with key stakeholders will also be crucial in understanding how important the data/information has been and what the implications would be of it not being available.

Key evaluation questions and sub-questions	Performance metrics *(broadly defined, specific metrics yet to be refined)*	Existing data sources *(collected as part of BAU)*	New data *(data specifically collected for the purposes of this evaluation)*	FPC comment
	○ use of air quality forecasts in the HRB/bushfires smoke management operations - activities of engagement, collaboration and knowledge transfer between CAS scientists and air policy staff	- Forecasters correspondence with other government agencies - Program records		
3.2 To what extent have people used /likely to use the information to reduce their personal exposure to air pollution?	**Effectiveness** - Number of subscribers to air quality alerts and forecasts in particular during pollution incidents (email/SMS) - Evidence (e.g. survey results) that community members use air quality information (forecasts and alerts) in taking actions to reduce personal exposure to air pollution	– **Database** for subscribers (trend in subscription data) – **User feedback** channels (via Air Quality Information and web feedback mailboxes, Environmental Line)	- **Social research** on general community (e.g. online pop-up survey of web users, or population-based survey) Independent consultant to work with program team	Feedback from community members (i.e. via survey) will be the most critical piece of evidence here, potentially paired with information that shows the scope of access and a small number of examples that illustrate how people have actually changed their behaviour.
KEQ 4: to what extent does the program present value-for-money?	**Value-for-money** - Social economic savings (dollars) from example actions to reduce exposure to air pollution - Funding total for the program in 2017-2022	– Financial data (SAP) – Exposure mapping research by Atmospheric Research Team	- Literature search on third-party exposure studies for NSW Independent consultant to work with program team	Likely to rely on comparing the costs of air pollution (done through other research) with program expenditure and subjective perceptions of its value.
KEQ 5: Were there any positive or negative unintended outcomes from the program				
5.1 What were the positive unintended outcomes of the program?	NA	NA	- Findings from this evaluation - Independent consultant to work with program team	These findings will rely almost entirely on input from staff and stakeholders, though there may be additional insights in program documents/reporting.

Key evaluation questions and sub-questions	Performance metrics *(broadly defined, specific metrics yet to be refined)*	Existing data sources *(collected as part of BAU)*	New data *(data specifically collected for the purposes of this evaluation)*	FPC comment
5.2 What were the negative unintended outcomes of the program?	NA	NA	- Findings from this evaluation Independent consultant to work with program team	As above

10 Appendix B – Air quality categories

Table 17. NSW Air quality categories as described at https://www.dpie.nsw.gov.au/air-quality/understanding-air-quality-data

			Air quality categories (AQC)				
Air pollutant	**Averaging period**	**Units**	**GOOD**	**FAIR**	**POOR**	**VERY POOR**	**EXTREMELY POOR**
Ozone	1-hour	pphm	<6.7	6.7–10.0	10.0–15.0	15.0–20.0	20.0 and above
O_3	4-hour rolling	pphm	<5.4	5.4–8.0	8.0–12.0	12.0–16.0	16.0 and above
Nitrogen dioxide NO_2	1-hour	pphm	<8	8–12	12–18	18–24	24 and above
Visibility Neph	1-hour	bsp	<1.5	1.5–3.0	3.0–6.0	6.0–18.0	18.0 and above
Carbon monoxide CO	8-hour rolling	ppm	<6.0	6.0–9.0	9.0–13.5	13.5–18.0	18.0 and above
Sulfur dioxide SO_2	1-hour	pphm	<13.3	13.3–20.0	20.0–30.0	30.0–40.0	40.0 and above
Particulate matter < 10 µm PM_{10}	1-hour	µg/m^3	<50	50–100	100–200	200–600	600 and above
Particulate matter < 2.5 µm $PM_{2.5}$	1-hour	µg/m^3	<25	25–50	50–100	100–300	300 and above

11 Appendix C – Survey of website and alert/forecast subscribers

1. **Does the air quality website help you to manage your health** (e.g. by influencing what you do in the day)?
   - **I often use it** to help make decisions/manage my exposure
   - **I sometimes use it** to help make decisions/manage my exposure
   - **I rarely use it** to help make decisions/manage my exposure
   - **I never use it** to help make decisions/manage my exposure
   - Not sure/Don't know

2. **How important is having access to air quality information for you?**
   - **Very important** (I need it and would be severely impacted without it)
   - **Important** (It's useful and I would miss it if it wasn't available)
   - **Somewhat important** (I use it, but would be okay without it)
   - **Not important** (I don't really use or need it)
   - Not sure/Don't know

3. **How satisfied are you with the information available on the website?**
   - Very satisfied
   - Satisfied
   - Neither satisfied or dissatisfied
   - Dissatisfied
   - Very dissatisfied
   - Not sure/don't know

4. **How could the information available better meet your needs?**

   _____

12 Appendix D – Performance indicators

Table 18. Summary of evidence against the performance indicators identified in the DPE Air Program evaluation plan.

Sub-questions	Performance indicator/ expectation	Assessment and notes
1.1 What worked well?	90% of projects delivered, or program milestones have been reached within planned/agreed timeframe and budget	Unable to be assessed because project documents did not specify timeframes or project-level budgets
	Evidence that air quality data and information services have been requested by a wide range of end-users	Good evidence that researchers, policy makers, regulators and the general public are seeking out data and information services – see Section 5.3
1.2 What were the barriers to efficient delivery and what improved success?	95% of projects where project design is enabling scientific rigor, stakeholder engagement and partnership	Unable to be assessed because comprehensive documentation on project-level design was not available in relation to project-level design and associated engagement/design considerations. Definition of this indicator is unclear.
	Evidence that the interested parties have worked collaboratively to design projects, and identify and resolve delivery issues	Good evidence of collaborative approach to project delivery based on broad range of stakeholder feedback – see Section 4.3
	Evidence that adaptive measures have been undertaken to manage the dynamically changing air quality information and service needs	Good evidence that staff and approach was adaptable to changing needs (e.g. Black Summer fires, website user feedback, etc.) - See Section 4.3.
	Evidence that air quality queries from major feedback channels have been responded within agreed timeframes	Good evidence that there were prompt responses. Note 'agreed timeframes' were not documented. See Section 5.4. Also, AQ Mailbox Reporting shows in April-July 2020, 36 enquiries were received. 25/35 (75%) of enquires responded to within 1-3 days, 5/35 (14%) within 4-7 days, and 5/35 (11%) taking more than seven days.
2.1 How well were the projects delivered by the program strategically relevant to end-user needs (NSW government policies, priories and strategies)?	All (%) projects clearly align with the program logic, government policies, priorities and/or strategies	All initiatives clearly aligned with the program logic and relevant policies/strategies – See Section 5.2.
2.2 To what extent was information widely diffused to business, community and	Over 80% of NSW population have access to air quality information and services, including business, community	Our analysis indicates some form of air quality monitoring occurs in SUAs that cover 6.1 million people, or 82% of the NSW population. Air quality forecasting, however, is not yet available outside Sydney. See Section 5.3.1.

Sub-questions	Performance indicator/ expectation	Assessment and notes
susceptible population sub-groups?	and susceptible population subgroups Over 80% of major population centres with access to air quality monitoring and forecasting services	Of the 21 SUAs with populations of more than 25k, 16 have some form of monitoring (76%). Air quality forecasting, however, is not yet available outside Sydney.
2.3 Do end-users and communities (*including population sub-groups*) have confidence in the quality, accessibility, *usefulness* and timeliness of program services?	Evidence of end-user activities for accessing/using air quality information, research, and web services	Good evidence that end-users are accessing raw air quality data, forecasts and 'real-time' air quality information on the website - see Section 5.3.4
3.1 To what extent have the program outputs been adopted to improve air pollution management policies and programs?	Evidence that program outputs have been used to improve major air pollution management policies and programs	Good evidence that the data/services provided under the Air Program has flowed through to management policies and decisions (see Section 6.2)
3.2 To what extent have people used/likely to use the information to reduce their personal exposure to air pollution?	Evidence that NSW community members use air quality information services (forecasts and alerts), by taking preventative actions such as limiting exercise/outdoor events during air pollution incidents	Good evidence that the data/services provided are used by the general public (particularly those sensitive to poor air quality) to guide their decisions and limit their exposure (see Section 6.3).
4: To what extent does the program present value-for-money?	The estimated cost saving outweighs the investment in the program	Cost-benefit analysis was outside the scope of this evaluation. However, indicative data suggests that, even with marginal reductions in the impacts of poor air quality enabled by the data provided by the Air Program would be more than its cost.