Cloud Seeding Program

2023 Operations Report
Published February 2025

snowyhydro

Snowy Hydro celebrates and acknowledges the traditional custodians of the many lands and waters on which we live and work. We pay our respects to Elders past, present and emerging for their custodianship of Country over centuries throughout Australia.

We recognise and honour the ongoing connection and deep spiritual relationship that Aboriginal and Torres Strait Islander peoples have to Mother earth and acknowledge the unique role they play in caring for and protecting her for future generations.

In line with the Snowy Hydro values of Safety, Teamwork, Ownership, Agility, Decency and Courage, we demonstrate our respect for First Nations peoples through our commitments to environmentally sustainable and ethical business practices and commit to working with Aboriginal people to grow and prosper communities while protecting our natural resources and ecosystems.

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Introduction

Snowy Hydro relies on precipitation falling over the catchments of the Snowy Mountains to supply water for the production of hydroelectricity. Cloud seeding over this area is used to enhance snowfall, ultimately leading to increased runoff and water available to produce energy.

Cloud seeding operations undertaken by Snowy Hydro are authorised by the *Snowy Mountains Cloud Seeding Act 2004* (NSW) (SMCS Act).

The SMCS Act mandates that cloud seeding operations may only be carried out in accordance with an Environmental Management Plan (EMP) approved by the Minister administering the *Environmental Planning and Assessment Act 1979*, and the Minister administering Part 4 of the *National Parks and Wildlife Act 1974* (the 'relevant Ministers').

Cloud seeding operations in 2023 were undertaken under the Cloud Seeding Program EMP that was formally approved by the relevant Ministers in July 2023. In accordance with the SMCS Act, the EMP must be reviewed at least once every five years. The NSW Environment Protection Authority (EPA) coordinated a five-yearly review of the EMP in 2023 in consultation with Snowy Hydro, the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW, formally NSW Department of Planning and Environment) and a range of stakeholders.

The SMCS Act requires Snowy Hydro, by 31 March in each year, to report on cloud seeding operations during the previous year to the relevant Ministers and to the EPA. The report must include details of compliance with the EMP and details of research monitoring the impact of seeding agents on the environment. The EPA is appointed to review each report on cloud seeding operations, and report the findings of the review and any resulting recommendations to the Board of the EPA and the relevant Ministers.

Snowy Hydro submitted the Cloud Seeding Program 2023 Annual Compliance Report to the relevant Ministers and the EPA in March 2024. The report demonstrated that Snowy Hydro has complied with all obligations set out within the EMP and responsibly carried out cloud seeding operations in accordance with the SMCS Act. Importantly, the 2023 Annual Compliance Report confirmed there continues to be no evidence of any significant adverse environmental impacts associated with cloud seeding activities.

The subsequent EPA review[1], published in December 2024, supported these findings.

This report includes details on cloud seeding operations in 2023, including:

- Operations, including the duration over which cloud seeding occurred and the total amount of cloud seeding agent released over the season;
- Meteorological monitoring, including controls to ensure precipitation falls as snow to at least 1,400 metres during cloud seeding operations and assessment of downwind impacts; and
- Environmental monitoring, including summary statistics of the monitoring program and details of research monitoring the impact of seeding agents on the environment

Finally, the findings and recommendations of the EPA review are provided.

1 Report on the findings of the NSW Environment Protection Authority's review of Snowy Hydro Cloud Seeding Program. 2023 Annual Compliance Report; received December 2024. Available from https://www.epa.nsw.gov.au/licensing-and-regulation/legislation-and-compliance/other-nsw-environmental-legislation/snowy-mountains-cloud-seeding-act-2004

Operations

Target area

The SMCS Act states that the area primarily targeted for increased precipitation must land within the Snowy water catchment.

An area of approximately 2,110 km² was targeted during 2023 cloud seeding operations. Figure 1 shows both the target area and the Snowy water catchment boundaries.

Hours of operation

The SMCS Act stipulates that operations are only to be carried out when precipitation is likely to fall as snow to at least 1,400 metres. Consequently, cloud seeding operations take place throughout the cool-season months, typically between May and October.

In 2023, a total of 36 hours and 16 minutes of cloud seeding occurred between 25 June 2023 and 09 September 2023.

Seeding agent and method of discharge

Silver iodide is the approved seeding agent. Silver is naturally present in the atmosphere, soil and sediments of the Snowy Mountains. Silver iodide is used as the ice nucleating material because it has similar physical properties to an ice crystal. It is also insoluble in water and does not become biologically available in the environment. In 2023, approximately 13.8 kg of silver iodide was dispersed over the 2,110 km² target area.

Land-based aerosol generators are the approved method to disperse the seeding material. The seeding agent is released by up to 23 ground-based generators located along the western perimeter of the target area when suitable atmospheric conditions are present.

Operational incidents

There were no accidents or breakdowns resulting in spillage of cloud seeding agents, cloud seeding fuel, or failure of controls specified in the EMP.

Snowy Hydro advised the EPA that a vehicle fuel leak occurred during weather station maintenance on an unsealed road on 14 February 2024. Snowy Hydro's internal Incident Management Procedures were followed. No material environmental harm was caused and corrective actions were put in place to prevent recurrence.

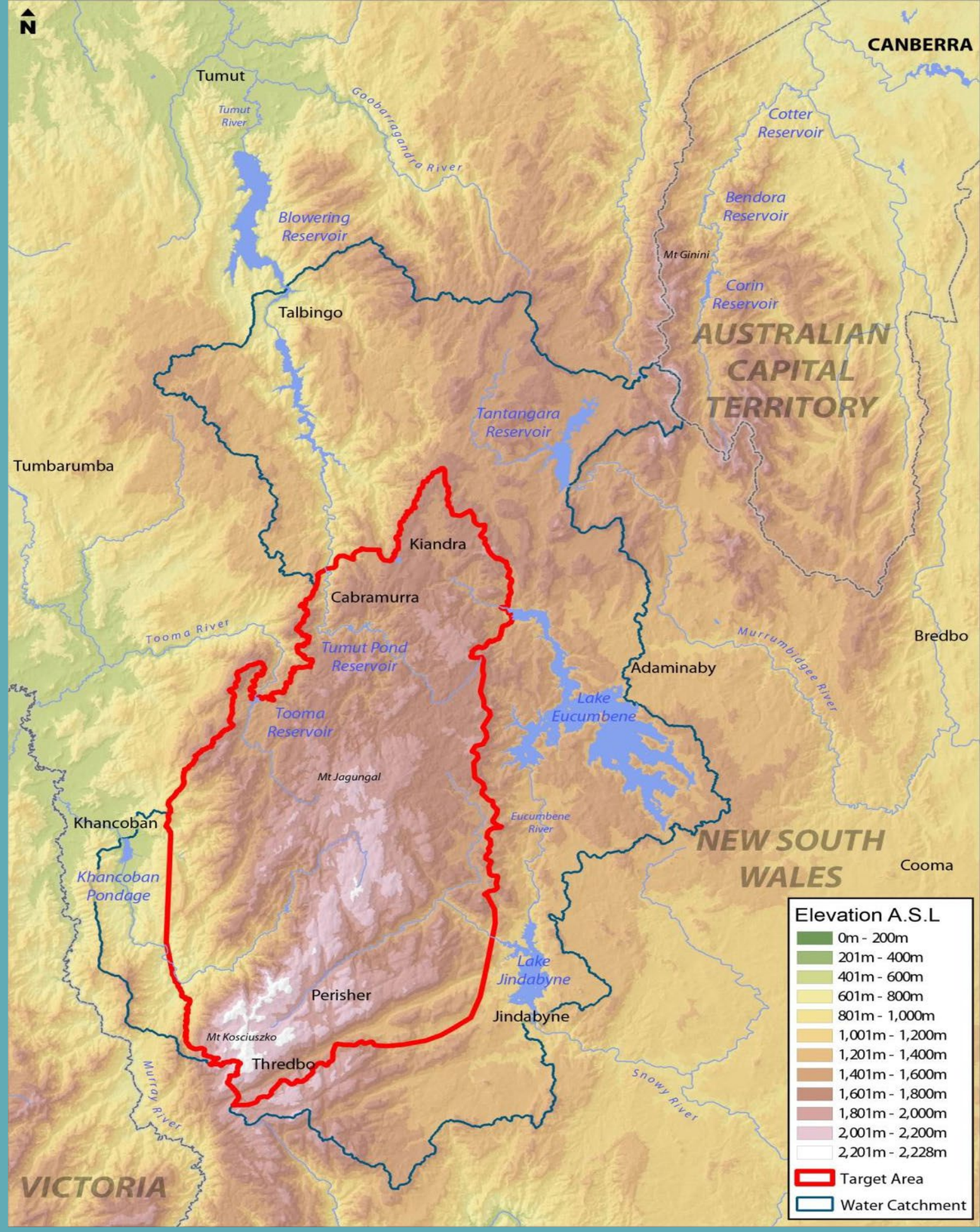

Figure 1: Map showing the Snowy water catchment (the area approved for cloud seeding) and the area which is primarily targeted for increased precipitation from cloud seeding operations (approximately 2110 km²).

Meteorological Monitoring

Snow level criterion

The SMCS Act mandates that the discharge of the seeding agent is to be carried out at a time when increased precipitation is likely to fall as snow to at least 1,400 metres above sea level.

Prior to 2023, compliance with the snow level criterion in the SMCS Act was demonstrated using temperature observations derived from weather balloons (radiosondes) manually released from Khancoban. In 2023, as part of the EMP review coordinated by the EPA, Snowy Hydro implemented improvements in meteorological monitoring methods in order to explicitly monitor the precipitation type falling at elevations near 1,400 m during cloud seeding operations. Three specialised sensors ('Parsivel disdrometers') were installed at elevations near 1,400 m that enable real-time monitoring of the precipitation type (i.e., snow, rain, drizzle, freezing rain and hail).

Weather balloons (radiosondes) are no longer required to be released from Khancoban to monitor atmospheric conditions for cloud seeding operations, improving operational safety and reducing the environmental impact caused by single use radiosondes and weather balloons.

During 2023:

- Cloud seeding operations only commenced when snow was falling to 1,400m
- There was one instance when mixed rain and snow was observed at 1,400m during operations leading to the suspension or termination of operations

Potential downwind impact

The Cloud Seeding Program has been designed so that additional precipitation from cloud seeding falls over the target area. A component of the design is routine monitoring of precipitation to identify any possible effects of cloud seeding extending outside the target area.

Data from the Bureau of Meteorology and Snowy Hydro weather stations provide the basis for comparison of the temporal and spatial variability of precipitation across the region during the winter months, both before and after cloud seeding operations commenced in 2004.

Analyses of precipitation amounts over 1990-2023 continue to show no evidence of an effect from cloud seeding on precipitation downwind of the target area. This supports the results of previous, independent analyses by the Natural Resources Commission (NRC)[2].

2 NRC Review of SPERP Annual Report 2011 (July 2012), available from https://www.nrc.nsw.gov.au/completed/cloud-seeding.

Environmental Monitoring

Environmental chemistry

Snowy Hydro has monitored silver concentrations in a range of environmental matrices at potential accumulation zones within and around the target area since the commencement of cloud seeding over the Snowy Mountains in 2004. Analyses of silver concentrations from samples collected prior to the commencement of cloud seeding in 2004 through to 2023 continues to show no evidence of any significant adverse environmental impacts associated with cloud seeding activities. The objectives of the monitoring program are to detect increases in the concentrations of silver compared with baseline concentrations, and to assess concentrations of silver compared with agreed guideline values of 0.1 mg/L for potable water and 1 mg/kg for all other matrices.

The EMP prescribes the number of sampling sites for each matrix and area, the replicates collected and analysed for each site and the sampling frequency. Once environmental samples are collected, they are sent to an independent laboratory for chemical analysis. The results are independently audited and analysed statistically.

In accordance with the EMP, all matrices with annual or five-yearly sampling frequency were sampled following the cessation of the 2023 season.

The silver concentrations in the 2023 potable water samples (unfiltered) were similar to those from previous years, with a mean concentration 0.00038% of the GTV (0.1 mg/L). Mean silver concentrations in the filtered potable water samples were 1.21% of the ANZG toxicant default guideline value for 99% species protection (0.02 µg/L, equivalent to 0.00002 mg/L). Due to the extremely low values observed in 2023 and in the previous surveys, no statistical analyses were undertaken for the potable water matrix.

The statistical analysis for all other matrices show silver concentrations consistent with previous years in the majority of sites. The concentration of total silver in four soil samples exceeded the GTV of 1 mg/kg (1,000,000 ppt). This is suspected to be related to fire activity from the 2019/2020 bushfires as these samples were collected in fire affected locations and had not been sampled since 2018, as per the five-year sampling frequency set out in the EMP. Bioavailable analysis of samples from these sites showed that bioavailable volumes of silver in these locations remains extremely low (i.e. well below 1% of the GTV), indicating the risk of toxicity in the environment or biological systems is extremely low.

Based on the outcomes of the environmental monitoring program, sampling will continue as outlined within the EMP. Potable water will continue to be sampled annually with additional resampling of selected soil locations in 2024 to further investigate the potential cause of the higher total silver concentrations at these sites. All other locations and matrices will be resampled following the conclusion of the 2028 cloud seeding season.

Summary statistics of silver concentrations are shown in Table 1a and 1b for potable water samples, and Table 2 for other matrices.

Table 1a: Summary of silver concentrations in 2023 potable water samples (mg/L). The guideline value for silver in potable water is 0.1 mg/L

Matrix	Number of samples	Minimum	Mean	Maximum	Guideline value
Potable Water	30	0.000000114	0.000000382	0.000003253	0.1

Table 1b: Summary of silver concentrations in 2023 filtered potable water samples (µg/L). The Australian and New Zealand Guidelines (ANZG) default guideline value for 99% species protection is 0.02 µg/L

Matrix	Number of samples	Minimum	Mean	Maximum	Guideline value
Potable Water	30	0.000040	0.000243	0.001524	0.02

Table 2: Summary of silver concentrations in 2023 soil, sediment, peat, and moss samples (mg/kg). The guideline value for silver in these matrices is 1 mg/kg

Area	Matrix	Number of samples	Minimum	Mean	Maximum	Guideline value
Control	River Sediment	11	0.013	0.079	0.141	1
Downwind	Soil	54	0.015	0.045	0.136	1
Generator	Soil	140	0.030	0.209	4.683	1
Intermediate	Soil	32	0.024	0.072	0.270	1
Target	Lake Sediment	15	0.006	0.016	0.034	1
Target	Meadow Soils	28	0.019	0.039	0.075	1
Target	Peat	38	0.026	0.136	0.595	1
Target	Reservoir Sediment	6	0.043	0.059	0.073	1
Target	River Sediment	43	0.009	0.021	0.072	1
Target	Soil	38	0.022	0.103	0.520	1
Target	Sphagnum Moss	46	0.002	0.017	0.066	1

Aquatic ecology

Statistical analyses of data collected following the 2023 season showed no evidence of any difference over time in the impairment of the macroinvertebrate assemblages or multivariate structure of edge or riffle assemblages which could be related to cloud seeding. Aquatic macroinvertebrates sampling will therefore take place after the 2028 cloud seeding season, in accordance with the EMP.

EPA Review

The EPA has undertaken a review of the Cloud Seeding Program 2023 Annual Compliance Report, in accordance with the SMCS Act and the EMP. In completing the review, the EPA consulted with the Department of Climate Change, Energy, the Environment and Water (DCCEEW) for the review of the report, and National Parks and Wildlife Service (NPWS) in respect to cloud seeding operations that took place within Kosciuszko National Park.

The EPA concluded:

- *Snowy Hydro has complied with all obligations as detailed in the Act*
- *Snowy Hydro has complied with all obligations as detailed in the Environmental Management Plan for cloud seeding operations approved by the relevant Ministers in July 2023*
- *Snowy Hydro has complied with all obligations as detailed in the Protection of the Environment Operations Act 1997*
- *Analysis of sampling across all matrices carried out during the 2023 cloud seeding season showed silver concentrations remain several orders of magnitude below relevant guideline values*

The recommendations were:

- *Monitoring should be continued as per the schedule of the EMP, and data compared over time to identify trends*
- *Future reviews are also undertaken in consultation with input from partner agencies of the NPWS and DCCEEW*
- *Snowy Hydro continues to pursue research opportunities on the cloud seeding operations in the Snowy Mountains*
- *The outcomes of this review are communicated to the relevant Ministers*

Pause in Cloud Seeding Operations

Following the end of the 2023 cloud seeding season, Snowy Hydro began a review of the Cloud Seeding Program. Snowy Hydro has paused cloud seeding operations while the review is being undertaken.

Conclusion

The Cloud Seeding Program 2023 Annual Compliance Report detailing cloud seeding operations and activities through 2023 was submitted to the relevant Ministers and EPA in March 2024. The EPA reviewed the report and confirmed Snowy Hydro has complied with all obligations set out in the SMCS Act and detailed within the EMP through the reporting period. There continues to be no evidence of any significant adverse environmental impacts associated with cloud seeding activities.

For more information about Snowy Hydro's Cloud Seeding Program please refer to our website, https://www.snowyhydro.com.au/generation/cloud-seeding/.

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