

**Report on the Findings of the  
NSW Environment Protection  
Authority's Review of  
Snowy Hydro Limited Cloud  
Seeding Program: 2013 Annual  
Compliance Report**

August 2014

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NSW Environment Protection Authority (EPA)  
59–61 Goulburn Street, Sydney  
PO Box A290  
Sydney South NSW 1232

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## 1 Executive summary

Snowy Hydro Limited (SHL) has been conducting a winter cloud seeding trial in the NSW Snowy Mountains area since 2004. On 31 May 2013, amendments to the *Snowy Mountains Cloud Seeding Act 2004* (the Act) came into effect, enabling SHL to conduct permanent cloud seeding operations within an expanded area of the Snowy Mountains in accordance with an Environmental Management Plan (EMP) approved by relevant Ministers. The Act defines the relevant Ministers as the Minister for the Environment and the Minister for Planning and Infrastructure, who approved the EMP on 5 July 2013. The Act also authorises aerial application of existing and alternative cloud seeding chemicals, and prescribed a review and oversight role for the NSW Environment Protection Authority (EPA). SHL is required to provide a report to the EPA detailing its compliance with the EMP and the results of any research and monitoring into the impact of cloud seeding operations on the environment by 31 March each year. The EPA is required to review this report and convey its findings, along with any recommendations, to the Board of the Environment Protection Authority and the relevant Ministers.

The EPA has reviewed SHL's annual compliance report for the 2013 cloud seeding season and has found that the compliance report was submitted to the relevant Ministers and the EPA by the due date and SHL has complied with all of its obligations as detailed in the Act and the approved cloud seeding EMP.

The EPA recommends that it undertakes an on-ground audit of cloud seeding operations in the 2014 snow-season and the findings of the review are communicated to relevant Ministers.

## 2 Introduction

### 2.1 Background

Cloud seeding is a process used to improve the capacity of orographic clouds to yield precipitation as snow. To achieve this, chemical particles are introduced - or seeded - into these clouds. Snowy Hydro Limited (SHL) uses silver iodide as the seeding particle in the Snowy Mountains. Silver iodide has physical properties very similar to natural ice crystals. In addition, silver iodide is practically insoluble in water, tends not to dissociate to its component ions of silver and iodine, and does not become biologically available in the environment. Instead, it remains as a solid in soils and sediments.

During cloud seeding operations, the seeded silver iodide particles combine with naturally occurring supercooled water droplets in the clouds to form ice crystals. These crystals then grow until they become too heavy to stay within the cloud and fall as snow.

To seed the clouds, ground based generators are arranged along the western side of the Snowy Mountain range. The generators are able to disperse minute quantities of the seeding agent into winter storm clouds as they pass across the range. Cloud seeding operations only target cloud systems travelling from west to east and when temperatures guarantee that precipitation will fall as snow above 1400 metres.

SHL has been conducting a winter cloud seeding trial in the NSW Snowy Mountains since 2004. Independent evaluation of the trial indicates that snowfall can be increased by an annual average of 14% through cloud seeding. Environmental monitoring has to date not detected any significant adverse environmental impacts. The 2013 cloud seeding operations comprised almost 106 hours of cloud seeding between 20 July and 22 August 2013. Approximately 45 kilograms of silver iodide was dispersed during these operations, covering a target area about 2110 square kilometres.

Under the *Snowy Mountains Cloud Seeding Act 2004* (the Act), cloud seeding operations may only occur in accordance with an Environmental Management Plan (EMP) that has been jointly approved by the relevant Ministers. This EMP was approved by the relevant Ministers on 5 July 2013.

The Act requires that SHL provide an annual report to the NSW Environment Protection Authority (EPA) and the relevant Ministers by 31 March, detailing its compliance with the EMP and the results of any research and monitoring into the impact of cloud seeding operations on the environment. The EPA is required to review this report and convey its findings, along with any recommendations, to the Board of the EPA and the relevant Ministers.

### 2.2 Purpose

The purpose of this report is to provide the Board of the EPA and the relevant Ministers with an overview of the findings of the EPA's review of SHL's Cloud Seeding Program 2013 Annual Compliance Report in accordance with the Act and the approved EMP.

## 3 EPA review of SHL annual compliance report

### 3.1 Review

The EPA has undertaken its review of SHL's Annual Compliance Report (the report), in accordance with the Act and the approved EMP. As part of this review, SHL provided the EPA with a short presentation summarising the 2013 cloud seeding operations and the associated meteorological and environmental monitoring. The Office of Environment and Heritage (OEH) Environment Protection Science Branch reviewed the 2013 annual compliance report and provided comments on the assessment of the monitoring data and identification of any environmental impacts. National Parks and Wildlife Service (NPWS) staff were also consulted on the cloud seeding operations that took place within Kosciuszko National Park.

### 3.2 Findings

The review of the 2013 Annual Compliance report found that:

- SHL has complied with all of its obligations as outlined in the Act and the EMP (Appendix 1)
- there were no accidents or breakdowns to report that resulted in spillage of cloud seeding agents or fuel, or failure of controls specified in the EMP
- monitoring was carried out in accordance with the EMP
- analysis of the monitoring data did not detect any evidence of significant adverse environmental impacts associated with cloud seeding activities
- cloud seeding is not having a significant effect on either the concentrations of silver in various parts of the environment or on the health of macro-invertebrate fauna at the test sites
- the 2013 monitoring results demonstrate that the 5-year monitoring cycle described in the approved EMP is appropriate
- there were no new operations involving land-based methods of discharge of seeding or tracing agent within any area of land managed under the NPW Act 1974
- no modifications or new facilities for cloud seeding operations were installed
- the NPWS carried out an inspection and audit of cloud seeding infrastructure within the Kosciuszko National Park on 10 January 2014 and found that the management of the cloud seeding sites was of a high standard with no non-compliances noted in respect to the site controls specified in the EMP.

### 3.3 Discussion

During 2013 cloud seeding operations, SHL dispersed approximately 45 kilograms of the approved seeding agent, silver iodide, into suitable storm systems. Meteorological conditions experienced in the Snowy Mountains during the 2013 cloud seeding season lead to an increased number of cloud seeding opportunities, which resulted in a slightly higher usage of silver iodide than in previous years. During the 2013 cloud seeding season, there were no new operations involving land-based methods of discharge of seeding or tracing agent within any area of land. There were also no modifications or new facilities installed for cloud seeding operations.

All of the environmental monitoring prescribed in the EMP was carried out by SHL. Analysis of this monitoring data was carried out to a high level and demonstrates that the continued use of silver iodide as the seeding agent is not having a significant effect on either the concentrations of silver in various parts of the environment or on the health of macro-invertebrate fauna at the test sites.

SHL, in conjunction with researchers from the University of Queensland, is continuing to investigate the environmental fate of silver in the Snowy water catchment deposited from both long-range natural sources and during cloud seeding operations. The findings of this research have been published in a scientific paper titled *Attribution of sources to metal accumulation in an alpine tarn, the Snowy Mountains, Australia*, which was published in the peer-reviewed journal *Environmental Pollution*. The final analysis and report into this study is expected to be completed in late 2014.

The EMP includes an adaptive environmental monitoring program where the future program is informed by the results of the previous environmental monitoring. The analysis of the 2013 environmental monitoring did not identify any adverse environmental impact. Accordingly, the EMP prescribes that a 5-year interval between environmental monitoring programs is appropriate.

An audit of the infrastructure within Kosciuszko National Park was carried out by the NPWS on 10 January 2014. This audit found that the on-ground management of the cloud seeding sites was of a high standard, and no non compliances were identified with the site controls specified by the EMP. These findings were further supported by the fact that there were no accidents or breakdowns to report that resulted in spillage of cloud seeding agents or fuel, or failure of any of the controls specified in the EMP.

### 3.4 Conclusions and recommendations

After reviewing the SHL 2013 Annual Compliance Report, the EPA concludes that:

- SHL has complied with all of its obligations as detailed in the Act
- SHL has complied with all of its obligations as detailed in the EMP for cloud seeding operations approved by the relevant Ministers on 5 July 2013
- management of the cloud seeding sites was found to be of a high standard and consistent with the site controls specified in the approved EMP
- environmental monitoring carried out during the 2013 cloud seeding season did not identify evidence of any significant adverse impacts on the environment from cloud seeding activities
- macro-invertebrate monitoring carried out during the 2013 cloud seeding season did not identify any evidence of any significant adverse impacts on the health of macro-invertebrates as a result of cloud seeding activities
- the 5-year interval between environmental monitoring programs prescribed in the approved EMP is appropriate and supported by the analysis of monitoring carried out during the 2013 cloud seeding season.

It is recommended that:

- the EPA conducts an on-ground audit of SHL's cloud seeding operations during the 2014 season
- future reviews are also undertaken in consultation with input from partner agencies of the NPWS and OEHS
- SHL 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.

## 4 Appendix 1

### 4.1 SHL compliance with the Snowy Mountains Cloud Seeding Act 2004

Obligations under the <i>Snowy Mountains Cloud Seeding Act 2004</i>	Compliance status (report reference)
The area to be primarily targeted for the increased precipitation is land within the Snowy water catchment.	(1.4) <b>Addressed</b>
Operations may be carried out only if there is an approved EMP.	(1.1) <b>Addressed</b>
Operations must be carried out in accordance with the approved EMP (whether being carried out within or outside the Snowy water catchment).	(1) <b>Addressed</b> All operations carried out within the catchment
The seeding agent used must be an approved seeding agent and used in accordance with the conditions (if any) of its approval as a seeding agent.	(2.2) <b>Addressed</b>
The tracing agent used must be an approved tracing agent and used in accordance with the conditions (if any) of its approval as a tracing agent.	(2.2) <b>Addressed</b> Tracing agent not used
The seeding agent and tracing agent must be discharged by the use of an approved method.	(2.2) <b>Approved</b> Land-based aerosol generators
The discharge must be carried out in accordance with the conditions (if any) of its approval as a method of discharge.	(2) <b>Addressed</b>
The discharge of the seeding agent is to be carried out at a time when increased precipitation in the Snowy water catchment is likely to fall as snow at an elevation above 1400 metres from the mean sea level.	(3.1) <b>Addressed</b>
SHL must consult with the NPWS before carrying out any new operations involving a land-based method of discharge of seeding or tracing agent within any area of land reserved under the <i>National Parks and Wildlife Act 1974</i> (that is, operations in an area that has not been the subject of previous consultation with the NPWS).	(2.3) <b>Addressed</b> No new operations carried out
SHL must consult with the NPWS before installing, or carrying out major modifications to, any facilities required to carry out cloud seeding operations within any area of land reserved under the <i>National Parks and Wildlife Act 1974</i> .	(2.3) <b>Addressed</b> No modifications or new installations carried out
Installation of new facilities for cloud seeding operations must not be carried out within any wilderness area (within the meaning of the <i>National Parks and Wildlife Act 1974</i> ).	(2.3) <b>Addressed</b> No new facilities installed



EPA Review of SHL Cloud Seeding Program: 2013 Annual Compliance Report

Obligations under the <i>Snowy Mountains Cloud Seeding Act 2004</i>	Compliance status (report reference)
A seeding agent is not to be discharged from land-based aerosol generators in any wilderness area (within the meaning of the <i>National Parks and Wildlife Act 1974</i> ).	(1.4) <b>Addressed</b> All land-based generators located in approved areas by NPWS
An application for approval of the use of a thing as a seeding agent in cloud seeding operations must be accompanied by details of the health risk assessment carried out in relation to the proposed use of the seeding agent (including the process used to carry out the assessment and the results of the assessment).	<b>(N/A)</b>
An application for approval of the use of a thing as a tracing agent in cloud seeding operations must be accompanied by details of the health risk assessment carried out in relation to the proposed use of the tracing agent (including the process used to carry out the assessment and the results of the assessment).	<b>(N/A)</b>
An application for approval of an EMP must be accompanied by an independent scientific assessment of any proposed cloud seeding operations that differ from the operations currently authorised. Any such scientific assessment must comply with any requirements imposed by the relevant Ministers and notified to SHL.	<b>(N/A)</b>
SHL must, by 31 March in each year or such later date as agreed by the relevant Ministers, provide a report on its cloud seeding operations during the period of 12 months ending on 31 December in the previous year to the relevant Ministers and to the EPA. Without limiting the generality of subsection (1), the report must contain the following information: (a) details of compliance with the approved EMP, (b) details of research concerning, and monitoring of, the impact of tracing agents and seeding agents on the environment (including the findings of any such research or monitoring).	(4) <b>Addressed</b> Report on cloud seeding operations received by EPA 28 March 2014

## 4.2 SHL compliance with the Environmental Management Plan

Obligations under the Environmental Management Plan	Compliance status (report reference)
<p>Cloud seeding will not commence if the freezing level over the catchment is greater than 1600 metres, and will be suspended or terminated if the freezing level rises above 1600 metres during cloud seeding campaigns.</p>	<p>(3.1) <b>N/A</b> Freezing levels above 1600 metres were never reached.</p>
<p>Additional controls will be implemented when the freezing level is between 1550 metres and 1600 metres ASL, including: (a) Video monitoring at locations over the target area at approximately 1400 metre elevation to assist in determining that precipitation is not falling as rain; and (b) when required, undertaking telephone polling to external parties and/or SHL personnel within the target area to confirm that precipitation is not falling as rain at approximately 1400 metre elevation</p>	<p>(3.1) <b>N/A</b> Freezing levels between 1550 metres and 1600 metres were never reached.</p>
<p>SHL will consult with the NPWS prior to undertaking major vegetation management and site access beyond maintenance of the existing tracks and site footprints.</p>	<p>(2.3) <b>N/A</b></p>
<p>The Annual Compliance Report will include (a) Sample locations, data results, evaluation and adaptive management recommendations for the environmental monitoring program; (b) Details (including results and evaluation) of any emerging environmental issues; (c) Results from meteorological monitoring that can demonstrate SHL's compliance with the requirement to ensure that increased precipitation falls as snow in areas at an elevation above 1400m ASL; (d) Results from analyses of downwind precipitation; (e) The event time and duration over which cloud seeding occurred; (f) Any accidents or break downs resulting in spillage of cloud seeding agents, fuel, or failure of controls specified in this EMP; (g) The quantity of cloud seeding agents that were released per seeding event per generator; and (h) Progress updates on the Environmental Fate Study if relevant (not including any project sensitive information, such as un-published data).</p>	<p>(a – 4.1-4.4) <b>Addressed</b> (b – 4.5) <b>Addressed</b> No emerging environmental issues. (c – 3.1) <b>Addressed</b> Table 4 (d – 3.2) <b>Addressed</b> Figure 2 (e – 2.1) <b>Addressed</b> Table 2 (f – 2.3) <b>Addressed</b> No accidents or breakdowns (g – 2.2) <b>Addressed</b> Table 3 (h – 4.3) <b>Addressed</b> Analysis and final report to be completed late 2014.</p>

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<b>Obligations under the Environmental Management Plan</b>	<b>Compliance status</b> (report reference)
<p>In addition to the Annual Compliance Report, SHL will also prepare a Cloud Seeding Operations Annual Report which is to be made publicly available on the SHL website within a reasonable timeframe after any recommendations from the Board of the EPA and the relevant Ministers. The Cloud Seeding Operations Annual Report will include, but not be limited to:</p> <ul style="list-style-type: none"> <li>• summary statistics of the Environmental Monitoring Program</li> <li>• details of compliance with approved EMP</li> <li>• summary statistics on the overall duration over which cloud seeding occurred and the total amount of cloud seeding agents that were released over the season.</li> </ul>	(1.2) <b>N/A</b>
<p>Disputes between NSW government agencies and SHL with regards to cloud seeding operations will be resolved in accordance with the following escalation process:</p> <ul style="list-style-type: none"> <li>• use of established paths of communication between SHL and the agency (officer to officer)</li> <li>• communication between SHL Executive Officer and agency Department Director</li> <li>• communication between the Chief Executives of SHL and the agency.</li> </ul>	(2.4) <b>Addressed</b> No disputes between NSW government agencies and SGL.
<p>SHL will continue to consult with other relevant land managers with respect to vegetation management and site access. SHL will also consult with relevant land managers in situations where major visual modifications are made to infrastructure or if new sites are installed and/or existing sites are removed. No new infrastructure will be established without the prior endorsement by the relevant land manager.</p>	(2.3) <b>Addressed</b> No new infrastructure established, no major visual modifications made to existing infrastructure, and no infrastructure decommissioned.
<p>OEH, the EPA and other identified stakeholders will be advised as soon as practicable following the commencement of, and on the conclusion of cloud seeding campaigns.</p>	(2.1) <b>Addressed</b> OEH and EPA and other identified stakeholders were advised by email.
<p>Existing sites authorised under the Act will be defined by SHL (coordinates and identified on a map), and provided to OEH and the EPA prior to commencement of first annual winter operations. Thereafter, prior to the installation of any new authorised sites, updated coordinates and maps are to be provided to OEH and the EPA.</p>	(1.4) <b>Addressed</b> A map of existing sites and details of their coordinates were provided to EPA and OEH in June 2013.

<b>Obligations under the Environmental Management Plan</b>	<b>Compliance status</b> (report reference)
<p>Implement all management controls (Table 1), being those included for each of the following activities:</p> <ul style="list-style-type: none"> <li>• installation and modification of generators</li> <li>• operation and maintenance of generators (including release of cloud seeding agents and increased precipitation)</li> <li>• storage and preparation of cloud seeding agents and other chemicals</li> <li>• installation and modification of weather stations</li> <li>• installation and modification of communications equipment</li> <li>• operation and maintenance of weather stations and communications infrastructure</li> <li>• operation and maintenance of snow sampling sites</li> <li>• Environmental Monitoring Program</li> <li>• removal of infrastructure and rehabilitation of sites.</li> </ul>	<p><b>(2.3) Addressed</b> Infrastructure, including cloud seeding agents and fuel, are managed in accordance with these requirements.</p>
<b>Meteorological monitoring</b>	
<p>Undertake monitoring of downwind precipitation – meaning wintertime daily precipitation anomalies will be updated each year and included in the Annual Compliance Report following cloud seeding operations to continue to monitor downwind precipitation.</p>	<p><b>(3.2) Addressed</b> Figure 2</p>
<p>Snow sampling profile sites and preferred access routes will be defined by SHL (coordinates and identified on a map) and provided to OEH and EPA prior to commencement of first annual winter snow sampling operations. Updated coordinates and maps are to be provided to OEH and EPA if sites change.</p>	<p><b>(1.4) Addressed</b> No snow profile sampling carried out in 2013. Sites and access routes will be provided to OEH and EPA prior to winter 2014.</p>
<b>Environmental chemistry monitoring</b>	
<p>Environmental sampling to be undertaken as per Table 3 in the EMP.</p>	<p><b>(4.1.2) Addressed</b> Table 5</p>
<p>Specific quality controls applied to the collection and handling of all samples collected for the cloud seeding program include:</p> <ul style="list-style-type: none"> <li>• the use of a new clean plastic vial/bag for each sample</li> <li>• the use of a new pair of clean disposable gloves at each site and procedures to minimise contact with the inside of vials/bags to minimise the potential for sample contamination</li> <li>• all sampling equipment is washed with ultra-pure water or water from the sampling location prior to use</li> <li>• the use of a data management system including the barcoding of each sample to ensure every sample is individually trackable from collection, return to base, dispatch to the laboratory and the return of results.</li> </ul>	<p><b>(4.1.3) Addressed</b> Samples are collected and processed in accordance with internal work instructions and quality assurance and quality control procedures.</p>
<p>Samples sent for laboratory analyses will be analysed for total silver concentration with an appropriate level of QA/QC.</p>	<p><b>(4.1.3) Addressed</b></p>

EPA Review of SHL Cloud Seeding Program: 2013 Annual Compliance Report

<b>Obligations under the Environmental Management Plan</b>	<b>Compliance status</b> (report reference)
For those samples that are analysed chemically, the data is to be analysed statistically and interpreted on the basis of three statistical tools.	(4.1.5) <b>Addressed</b>
Implementation of steps in decision tools and environmental suspension criteria.	(4.1.1, 4.1.5) <b>Addressed</b>
The interim and final results of the Environmental Fate study will be provided to OEH and the EPA upon peer-reviewed publication. In addition, if required, briefings on the project will be provided to OEH and the EPA including any recommendations for the adaptive management of the environmental monitoring program.	(4.3) <b>Addressed</b> Final report to be completed late 2014.
Research findings from the study will be used to inform the Environmental Monitoring Program and may result in the improvements to the current program, if required.	(4.3) <b>Addressed</b>
<b>Macroinvertebrates monitoring</b>	
Sampling will be undertaken on a 5-year sampling interval, with the first round of sampling to be undertaken following the first year of cloud seeding operations. In the event that additional river sediment sampling is required as a result of the triggers outlined in Section 5.2.7, macroinvertebrates sampling will also be undertaken at the affected locations.	(4.2) <b>Addressed</b> No linear relationship between the concentration of silver in aquatic sediments and impairment of macroinvertebrate fauna.
If macroinvertebrate sampling sites are changed and/or added outside of the EMP Review process, updates to Table 7 will be provided to EPA/OEH prior to sampling being undertaken.	(4.2) <b>Addressed</b> Figure 3
The macroinvertebrate sampling program implemented by SHL (and endorsed by OEH) uses the NSW AUSRIVAS protocol	(4.2) <b>Addressed</b>
<b>Additional monitoring</b>	
Relevant agencies of the Minister for the Environment may request consideration by SHL of emerging environmental issues between reviews of this EMP. In order for issues to be considered by SHL, the agency will provide a clear outline of the issue to SHL based on direct evidence or established scientific theory. The agency and SHL will then agree on an appropriate research / monitoring / consultation / reporting regime.	(4.5) <b>Addressed</b> No emerging environmental issues have been raised with, or identified by, SHL during this reporting period.

## 5 Appendix 2

### Review of the scientific components of 'Cloud Seeding Program; 2013 Annual Compliance Report; March 2014' by Snowy Hydro Limited

SF14/9972

#### Issue

Science Division has reviewed the report by Snowy Hydro on environmental monitoring of 2013 cloud seeding operations.

#### Recommendations

Environment Protection Branch, Science Division, Office of Environment and Heritage suggest:

1. The scientific components of the Snowy Hydro Annual Compliance Report 2013 be accepted contingent on the two factual errors reported below being corrected.
2. Based on the data in that report and consistent with the Environmental Management Plan the next round of environmental monitoring be done in 2018.
3. Snowy Hydro be reminded of the obligation to alert EPA early should Snowy Hydro propose changes to the delivery of seeding agent, so that amendments to the monitoring plan can be negotiated.

#### Background

Snowy Hydro has submitted its report: **Cloud Seeding Program; 2013 Annual Compliance Report; March 2014** to the EPA for review as required by legislation. EPA has requested that OEH Science Division review the environmental monitoring sections of the report and provide comment on the adequacy of the reporting and the environmental impacts, if any, which have been detected.

#### Current position

Environment Protection Science (EPS) Branch of the OEH Science Division has completed an assessment of the scientific components of Snowy Hydro's report. We have reviewed Chapter 4 of the report and all relevant appendices referenced in that Chapter (i.e. the Cardno reports to SHL).

EPS considers this to be good report with the recommendations supported by the analysis of the data. In essence, the report shows that that cloud seeding is not having a significant effect on either the concentrations of silver in various parts of the environment or on the macroinvertebrate fauna at the test sites.

Where statistically significant increases have been detected they are so small that, in accordance with the EMP, a 5-year monitoring cycle is appropriate in future. Modelled times to reaching the Guideline Trigger Value are many times the agreed 20-year timeframe, sometimes orders of magnitude greater.

EPS has picked up two factual errors in the report that need to be corrected:

**p 179:** 1<sup>st</sup> paragraph refers to 'CMA regions'; should now refer to LLS regions

**p 211:** 1<sup>st</sup> paragraph under the heading 'Edge Fauna' is incorrect, this paragraph refers to riffle fauna

The report recommends that, because no significant impacts have been detected and consistent with the Environmental Management Plan (EMP), future monitoring should be

done at 5-year intervals. EPS agrees with this recommendation. There is no evidence to suggest that shorter timeframes are required.

Snowy Hydro has not altered the mode of delivery of the seeding agent, nor the method of delivery during this 2013 season. The new Act under which cloud seeding is now done permits a range of activities that have not been part of the operation until now. They include seeding from aircraft and also using different seeding agents. In 2013 the monitoring was consistent with what has been done before and monitoring was done in accordance with the EMP. The Act requires amendments to the EMP if those modes are altered and so, early discussions between EPA and Snowy Hydro are necessary if Snowy Hydro should propose to alter those modes in the future. This would be necessary to test whether new methods have different effects on environmental chemistry and ecosystems than the previous methods used. If they are planning to continue to use silver iodide dispensed from ground stations, then monitoring will not be required until the winter of 2018



Klaus Koop

26 May 2014