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In 1967 the Australian state of Victoria passed a Rain-making Control Bill. Victoria has many of the same geographical and climatic features as states in the arid regions of the United States. Consequently, these American states have the opportunity to observe the Victorian experience and apply these observations to their own situation. Professor Davis renders the Rain-making Control Bill even more relevant by comprehensively analyzing all aspects of the statute and drawing comparisons with American weather modification legislation.

THE LAW OF PRECIPITATION ENHANCEMENT IN VICTORIA

*Ray Jay Davis**

AUSTRALIA is the most arid of the continents. Mark Twain was supposed to have commented that only the "hardier rocks" could survive in its dry weather. While the world has an average rainfall of twenty-seven inches, Australia's average is only sixteen and a half inches.¹ Only a third of the continent receives between twenty and fifty inches of rain a year; the remainder suffers from an inadequate fall of between five and twenty inches. In some years in the dry south central region no precipitation falls at all.²

Generally speaking, the immediate physical cause of precipitation is the lifting of moist air with resultant cooling, condensation into a cloud, and fallout from the cloud of raindrops or snowflakes. This lifting process may be achieved by three means acting alone or in any combination: (1) orographic lifting caused by winds blowing onto rising terrain; (2) convectional lifting through which vertically rising buoyant par-

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1. POWNALL, *THE THIRSTY LAND: HARNESSING AUSTRALIA'S WATER RESOURCES* 13-14 (1968).

2. CAMPBELL, *DROUGHT: CAUSES, EFFECTS, SOLUTIONS* 12 (1968).

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cels of air are cooled; (3) lifting of a warm air mass as it rises over cooler air, a frontal process.³ Australia's average height above sea level is only nine hundred feet, and its few mountain ranges are low by world standards.⁴ This flattish surface is one of the reasons for the low rainfall average.

There also is a high degree of variability in Australian precipitation patterns with resultant frequent droughts.⁵ This in turn causes a variation in stream flow. The ratio of the maximum to minimum annual flow of European rivers is about five. Only the Snowy River in the mountains of the southeast of Australia has that low of a ratio. The Murray, the country's and Victoria's most important stream, has a ratio of twenty-seven at one gauging station; the Darling, which is the longest tributary of the Murray, has a variability index of ten thousand.⁶

The six state capital cities are all located on or near the oceans at the mouths of rivers where fresh water supplies made them attractive for early settlement. Over half of the nation's people live in these cities, and an additional quarter of the population live in the other urban centers, which are also generally on streams near the oceans.⁷ In spite of its "bush" myth, the Australia of today is a highly urbanized society. Lack of adequate interior water resources has played an important role in bringing this about.

The Australians have constructed extensive water management facilities in order to meet the needs of their growing cities and vast agricultural lands. Just after the turn of the century a pipeline was laid to transport water over three hundred fifty miles to the interior mining town of Kalgoorlie in Western Australia.⁸ Extensive development of artesian wells has made vast "outback" areas of Queensland useful for grazing and agriculture.⁹ The Snowy Mountain Scheme has

3. ARCHER, OFFICIAL YEAR BOOK OF THE COMMONWEALTH OF AUSTRALIA, No. 54 at 28 (1968). See also BUREAU OF METEOROLOGY, MANUAL OF METEOROLOGY 65-69 (1966).

4. CAMPBELL, *supra* note 2, at 13.

5. See FOLEY, DROUGHTS IN AUSTRALIA (Bureau of Meteor. Bull. No. 43, 1957).

6. CAMPBELL, *supra* note 2, at 22.

7. MCGREGOR, PROFILE OF AUSTRALIA 19 (1966).

8. POWNALL, *supra* note 1, at 43-45.

9. *Id.* at 26-34.

turned rivers inland to benefit the peoples of New South Wales, South Australia, and Victoria.¹⁰

WEATHER MODIFICATION

It first occurred to the aboriginies that rain-making would be another means of coping with the problem of inadequate water resources. Their medicine men used magic stones as accessories in exercising control over the weather. Such media were employed in secret ceremonies and were not to be handled by the uninformed, lest they be used improperly. Aboriginal rain makers were averse to practicing their art unless there was a reasonable chance of natural rainfall. To handle the problem of too much success, they took the precaution of devising rain-stopping ceremonies as well.¹¹

In the 1890's Clement Wragge, the Queensland state government meteorologist, undertook the first experiment intended to induce rainfall. He built a vortex gun and proceeded to an area of the state suffering from a severe drought. Unfortunately there were few clouds about, and firing at them failed to bring down any precipitation.¹²

Early in 1947 a successful experiment was conducted in New South Wales, where scientists of the Radiophysics Division of the Commonwealth Scientific and Industrial Research Organization created the first artificial rain to reach the ground anywhere.¹³ They employed the method of dropping dry ice pellets from aircraft into clouds. The preceding year Vincent Schaefer of the General Electric Research Laboratory in Schenectady, New York had discovered that a profusion of ice crystals could be produced in a laboratory cold box by the introduction of dry ice. On November 13, 1946 he tested his discovery in the atmosphere by dumping three pounds of dry ice into a cloud over Pittsfield, Massachusetts. His superior, the Nobel Prize winner Irving Lang-

10. *Id.* at 76-150.

11. **ABBIE**, *THE ORIGINAL AUSTRALIANS* 155 (1969). The first reference to weather modifications in Australian legal periodical literature suggests that "it might perhaps from all points of view better be left as heretofore in the relatively safe hands of the darker inhabitants of our continent." **Harry**, *Another Headache*, 26 *AUSTL. L.J.* 527 (1953).

12. **SHIELDS**, *AUSTRALIAN WEATHER* 110 (1965). For an account of an American effort to blast the weather see Lyons, *Weather or Not*, 8 *ARIZ. Q.* 5, 6 (1952).

13. **Higgs**, *Rainmaking in Australia*, No. 338 *SHELL AVIATION NEWS* 16 (1966).

muir, watched and saw snow fall for about two thousand feet from the cloud before it evaporated. The dry ice had triggered the formation of ice crystals and induced the precipitation.¹⁴

Soon after the development of dry ice seeding, it was discovered by Bernard Vonnegut, another General Electric scientist, that proper treatment of cold clouds with silver iodide could improve their precipitation efficiency.¹⁵ This alternative approach was adopted by the Commonwealth Scientific and Industrial Research Organization because of the prohibitively large quantities of dry ice needed to seed over large areas. They began burning a solution of silver iodide in acetone, using simple burners or generators mounted on the wings of aircraft. This produced a smoke plume containing minute hexagonal silver iodide crystals which have dimensions almost identical with those of ice crystals. The silver iodide particles trigger precipitation by serving as the nuclei for attraction of cloud droplets which grow large enough to fall to the ground as precipitation. The cloud seeding process thus produces artificial nucleation and, when properly done under the right conditions, enhances precipitation.¹⁶

All of the experimental work on weather modification in Australia has been performed by the Commonwealth Scientific and Industrial Research Organization (CSIRO).¹⁷ It is a large federal agency financed primarily by the government of the Australian Commonwealth and dedicated to scientific research which can be applied to improve the nation's

14. HALACY, *THE WEATHER CHANGERS* 84 (1968). Reports on dry ice seeding in Australia may be found in Smith, *The Influence of Meteorological Conditions on Rainmaking in the Sydney Area*, 5 *AUSTL. J. SCIENTIFIC RESEARCH* 87 (1952); Smith, *Experiments in Seeding Cumuliform Cloud Layers With Dry Ice*, 2 *AUSTL. J. SCIENTIFIC RESEARCH* 78 (1949); Squires & Smith, *The Artificial Stimulation of Precipitation by Means of Dry Ice*, 2 *AUSTL. J. SCIENTIFIC RESEARCH* 232 (1949); Kraus & Squire, *Experiments on the Stimulation of Clouds to Produce Rain*, 149 *NATURE* 489 (1947).

15. BATTAN, *CLOUD PHYSICS AND CLOUD SEEDING* 94 (1962).

16. For discussions of process and effectiveness of weather modification see CRITCHFIELD, *GENERAL CLIMATOLOGY* 261-65 (2d ed. 1966); MASON, *CLOUDS, RAIN AND RAINMAKING* (1962); OFFICE OF ATMOSPHERIC WATER RESOURCES, *PLAN TO DEVELOP TECHNOLOGY FOR INCREASING WATER YIELD FROM ATMOSPHERIC SOURCES* (1966); PANEL ON WEATHER AND CLIMATE MODIFICATION, NATIONAL ACADEMY OF SCIENCES, *WEATHER AND CLIMATE MODIFICATION: PROBLEMS AND PROSPECTS* (1966); SPECIAL COMMISSION ON WEATHER MODIFICATION, NATIONAL SCIENCE FOUNDATION, *WEATHER MODIFICATION AND CLIMATE MODIFICATION* (1966); VAN STRATEN, *WEATHER OR NOT* 187-230 (1966).

17. Hereinafter referred to as CSIRO.

agriculture and industry.¹⁸ The Radiophysics Division of CSIRO was set up during World War II to improve radar and adapt it for use in Australia and the South Pacific areas where Australian troops were fighting.¹⁹ After the war, the Division turned its efforts to two applications of radar technology—radiotelescopes and radar meteorology. The latter evolved into the interest in weather modification. After the retirement in 1971 of E. G. Bowen, who had headed the Division throughout its period of weather modification work, the cloud seeding personnel were split off from the radio astronomers and merged with an existing Division of Atmospheric Physics.²⁰

CSIRO has conducted cloud seeding experimental work throughout Australia. They have, for example, worked in the Snowy Mountains of New South Wales and Victoria,²¹ the New England area of northern New South Wales,²² and in South Australia.²³ Initial work was on individual clouds; later they went to area experiments.

Cloud seeding depends for its effectiveness upon having the right meteorological conditions. In much of the center of Australia clouds are rare. You cannot seed nonexistent clouds. But in Victoria there are appropriate weather conditions for a precipitation enhancement program. The rainfall is highest on the windward side of the Snowy Mountains in

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18. Science and Research Act 1949-1968 (Austl.). The scope of its activities can be seen by examining its annual reports. *E.g.*, CSIRO TWENTY-SECOND ANNUAL REPORT (1969-70). Its 1970-71 budget exceeded \$72,000,000 in American currency. CORESEARCH 1, col. 1 (Sept. 1970).
 19. MELLOR, THE ROLE OF SCIENCE AND INDUSTRY: AUSTRALIA IN THE WAR OF 1939-1945 at 431-84 (1958).
 20. Interview with E. E. Adderley, CSIRO Scientific Counselor to Japan, in Canberra, Australia, Sept. 8, 1971.
 21. Adderley & Twomey, *An Experiment on Artificial Stimulation of Precipitation in the Snowy Mountains Region of Australia*, 10 TELLUS 275 (1958); Smith, Adderley & Walsh, *A Cloud-Seeding Experiment in the Snowy Mountains, Australia*, 2 J. APPLIED METEOR. 324 (1963).
 22. Smith, Adderley & Bethwaite, *A Cloud-Seeding Experiment in New England, Australia*, 4 J. APPLIED METEOR. 433 (1965).
 23. Smith, Adderley & Bethwaite, *A Cloud-Seeding Experiment in South Australia*, 2 J. APPLIED METEOR. 565 (1963). For studies of weather modification activities generally in Australia, see SMITH, POSSIBILITIES OF ARTIFICIAL MODIFICATION OF PRECIPITATION, in WATER RESOURCES USE AND MANAGEMENT 80 (Hills ed. 1963); Higgs, *Rainmaking in Australia*, 3 HEMISPHERE 2 (1959); Kraus, *Water for Australia?*, AUSTL. Q., Mar. 1951, at 81; Smith, *Effects of Cloud-Top Temperature on the Results of Cloud Seeding with Silver Iodide in Australia*, 9 J. APPLIED METEOR. 800 (1970); SMITH, *Cloud Seeding Experiments in Australia*, in PROCEEDINGS OF THE FIFTH BERKELEY SYMPOSIUM ON MATHEMATICAL STATISTICS AND PROBABILITY 161 (1965-66).

the eastern part of the state; the Grampians in southwestern reaches provide an orographic uplift that induces rainfall. However, a third of the state has between ten and twenty inches average rainfall.²⁴

In 1966 a drought afflicted Victoria, along with much of the rest of the country. The State Department of Agriculture carried out a cloud seeding program in the wheat raising Wimmera-Mallee area in the western part of the state during August, September, and October.²⁵ The Forests Commission seeded forest areas east of Melbourne during January and February, when conditions were suitable for treatment.²⁶ These operations, designed to relieve drought, were financed from the state treasury. Planning the operations and carrying them out were made easier by using CSIRO experience and information.

WEATHER MODIFICATION LEGISLATION

Because of Australia's tradition of government involvement in water resources development, the 1966 drought brought urgent calls to CSIRO to engage in operational drought relief programs.²⁷ Dr. Bowen and his co-workers felt that extensive involvement by them in efforts to ameliorate the drought would divert their energies from experimentation and developmental work. Carefully designed experiments call for creation of control areas which are not seeded, as well as seeding areas. Even in experimental areas seeding is done only on a randomized basis. Assessment of precipitation and other data could yield information about the success of the artificial nucleation techniques employed. Operations de-

24. ARCHER, *supra* note 3, at 29.

25. Adderley, *A Change in Rainfall Gradient in Western Victoria and Its Effect on the Assessment of the 1966 Cloud-Seeding*, 17 AUSTL. METEOR. MAG. 97 (1969); ADDERLEY, *Rainfall Increases Down-Wind from Cloud Seeding Projects in Australia*, in PROCEEDINGS OF THE FIRST NAT'L CONFERENCE ON WEATHER MODIFICATION 42 (1968); Adderley, *Cloud Seeding in Western Victoria in 1966*, 16 AUSTL. METEOR. MAG. 56 (1968); O'Mahony, *Cloud-Seeding in Western Victoria in 1966*, 17 AUSTL. METEOR. MAG. 63 (1969); O'Mahony, *Cloud Seeding in Wimmera-Mallee, Victoria, 1966*, 15 AUSTL. METEOR. MAG. 133 (1967); White, *Secular Trends in Target/Control Area Ratios, 1925-66, Used In Analysis of Cloud-Seeding in Victoria, 1966*, 17 AUSTL. METEOR. MAG. 95 (1969).

26. INTERDEPARTMENTAL COMMITTEE ON CLOUD SEEDING IN VICTORIA TO PROMOTE RAINFALL, Report 9 (1967) [hereinafter cited as COMMITTEE REPORT].

27. Interview with E. G. Bowen, Head of Radiophysics Division, CSIRO, in Epping, New South Wales, Nov. 19, 1971.

signed to relieve drought conditions call for seeding at every opportunity. Carried out in an area where an experiment was in progress, such operations would destroy its integrity. This was an added reason for the Radiophysics Division's desire to avoid getting into operational seeding.²⁸

The Commonwealth government is Australia's primary tax gathering agency. It, however, dispenses large revenue grants to the states.²⁹ There is more or less constant pressure from them upon the federal government to increase the size of their grants and to embark upon federally financed programs benefiting the states. Involvement of CSIRO in operational precipitation enhancement would be such an undertaking. The states would reap the harvest, and the federal government would seed the clouds.

In correspondence among Dr. Bowen, Sir Frederick White, then Chairman of CSIRO, and John Gorton, then Minister in charge of CSIRO, these federal officers decided that the states should be encouraged to enter the cloud seeding field themselves and that the Commonwealth, acting through the Radiophysics Division of CSIRO, should assist the states by providing them with information and training their cloud seeding officers. The state governments and not the federal government were to finance weather modification activities.³⁰

After correspondence with several state premiers, the Acting Prime Minister, John McEwen, wrote the premiers on July 11, 1966, offering them the assistance of CSIRO in training of operators and advice on operations. He suggested that it would be appropriate for each state to give serious thought to cloud seeding and noted that "to prevent possible exploitation of the man on the land, it would seem desirable that control and management of these activities should be in the hands of your Government."³¹

28. *Id.*

29. This is authorized under the Commonwealth of Australia Constitution Act §§ 96, 105A.

30. Letters of E. G. Bowen to Frederick White, March 11, March 18 and April 28, 1966; Letters of Frederick White to E. G. Bowen, April 14 and May 2, 1966; Letter of John Gorton to Frederick White, April 6, 1966; Letters of Frederick White to John Gorton, March 22 and May 27, 1966.

31. Letters of John McEwen to Premiers of Victoria, South Australia, Tasmania, and Western Australia, July 11, 1966. Similar letters were sent to the Premiers of New South Wales and Queensland. The correspondence referred to in this note and the preceding one is on file at the Division of Atmospheric Physics laboratory at Epping, New South Wales.

Arising from this communication, the government of Victoria formed an officer committee to investigate the interests of the departments of the state government in seeding, the need for legislation, and other related matters.³² The committee recommended cloud seeding operations by government agencies on a regular rather than limited, scale; and it made extensive legislative proposals. It was the view of the members of the committee that, even though some of their recommendations on operations related only to a trial period, "the immediate provision of statutory authority to control operations in the best interests of the community as a whole is preferable to waiting until litigation demonstrates the need for such legislation."³³

The Victorian government accepted the report and acted upon it by presenting to the state parliament for its approval a Rain-making Control Bill. During parliamentary discussions in October, November, and December of 1967, the proposal was favorably received, and the opposition parties as well as the majority supported it. There were some quibbles and a few expressions of concern³⁴ but no very sturdy objections. The bill was enacted into law on the nineteenth of December, 1967.³⁵ The statutory rules which supplement the act were promulgated in April 1968.³⁶

The other states have not passed laws dealing specifically with weather modification. In Western Australia, Queensland, and South Australia there has not recently been much cloud seeding. Like American states where little is being done, they could see no need for a law.³⁷ New South Wales appointed a committee, like the Victorian group, which con-

32. COMMITTEE REPORT 1, *supra* note 26.

33. *Id.* at 18.

34. 1967 PARL. DEB. 602-06, 3106-13, 1415-23 (Vict.). Among the objections were adverse comments about failure of the bill to define the term "Minister" and its alleged excessive delegation of the rule-making power.

35. Rain-making Control Act of 1967, Act. No. 7637, 1968 VICT. GOV'T. GAZ. 707 [hereinafter cited as Act].

36. Rain-making Control Regulations 1968, Statutory Rule No. 98 [hereinafter cited as Rules].

37. There are no laws directly relating to cloud seeding in twenty of the American states. For a study of state legislation in the United States see Davis, *State Regulation of Weather Modification*, 12 ARIZ. L. REV. 35 (1970).

ducted a similar inquiry into the question of the need for a law;³⁸ no statute resulted from its efforts. In Tasmania the Hydroelectric Commission has been involved with CSIRO in experimental activities to determine the benefits it can derive from using cloud seeding to increase runoff into the wide network of reservoirs it operates as part of its power generation system.³⁹ The Commission had, however, earlier obtained legislation exempting it from being enjoined from carrying out its activities.⁴⁰ The Commissioner felt that proposals to the state parliament for specific legislation on weather modification might result in a law that would inhibit their cloud seeding efforts.⁴¹

OPERATIONAL AUTHORITY

The Victoria Rain-making Control Act is designed to protect the "man on the land" by restricting weather modification activities to those for which an operational permit or authority has been granted. It additionally provides a framework for setting operational conditions, and it refers to liability for harm caused by seeding. But the key provisions are those concerning authorization of activities, exemptions from the permit requirement, and the effect of conducting unauthorized rain-making.

Section 3 of the law delegates power to the "Minister" to authorize carrying out of rain-making operations.⁴² Under the regulations the term "Minister" is defined as the Minister of Agriculture in the state government.⁴³ The investigatory committee had suggested in a proposal of its report that an advisory committee be set up to make recommendations on seeding programs in the state.⁴⁴ Such an interdepartmental

38. NEW SOUTH WALES DEPARTMENT OF AGRICULTURE COMMITTEE ON CLOUD SEEDING, REPORT TO DIRECTOR GENERAL (1966).

39. Bowen, *Cloud Seeding*, SCIENCE J. Aug., 1967, at 2; SMITH, *Cloud Seeding With Pyrotechnics In Australia*, in PROCEEDINGS OF THE SECOND NAT'L CONFERENCE ON WEATHER MODIFICATION 186 (1970); SMITH & ADDERLEY, *A Cloud-seeding Experiment in Tasmania*, in PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON WEATHER MODIFICATION, CANBERRA, AUSTRALIA (1971).

40. TASM. STAT. § 7 (Act No. 31, 1967).

41. Interview with Sir Alan Knight, Hydroelectric Commissioner, in Hobart, Tasmania, Sept. 16, 1970.

42. Act § 3.

43. Rules § 3.

44. COMMITTEE REPORT 3, *supra* note 26.

advisory committee has been formed with representatives from the Department of Agriculture, the Rivers and Water Supply Commission, the Forests Commission, the Electricity Commission, and the Melbourne and Metropolitan Board of Works. These are the major water development, management, and use agencies of the state of Victoria. Recommendations from the advisory committee are considered by the Minister of Agriculture in exercising his power to authorize cloud seeding. Indeed, within the limits of the funds available from the Treasury for state-financed operations, the advisory committee's recommendation becomes the Minister's decision.⁴⁵

From time-to-time private individuals and companies have sought advice from CSIRO on how to set up and operate a rain-making project. They have been dissuaded from going into the business of explanations of the scientific difficulties and suggestions of potential legal problems.⁴⁶ Cloud seeding in Australia has consequently been a government monopoly. In the other states this is a matter of practice; in Victoria it is now a matter of law. Section 4 of the Victorian law states that "where the Minister authorizes rain-making operations . . . he shall issue his authority to some officer or body under his control to make arrangements for carrying out those operations."⁴⁷ There is no mention of any power to license a private operator to conduct weather modification activities.

All "authorities" which have been granted have been issued to the Agricultural Aviation Section of the Department of Agriculture. The major role of this agency is the enforcement of Victoria's crop dusting and environmental protection legislation.⁴⁸ It has, however, carried out seeding operations on behalf of the various interested departments of the government.⁴⁹ During 1970, authorities were issued to it to perform rain-making from an aircraft based on Horsham, Victoria,

45. Interview with Rod Kefford, Principal Executive Officer, Victoria Department of Agriculture, Agricultural Aviation Section, in Melbourne, Victoria, Sept. 14, 1970.

46. Interview with E. E. Adderley, CSIRO Radiophysics Division, in Epping, New South Wales, Oct. 26, 1970.

47. Act § 4.

48. Interview with J. P. Bearham, Victoria Department of Agriculture, in Canberra, Australia, Sept. 8, 1971.

49. Interview with Rod Kefford, Principal Executive Officer, Victoria Department of Agriculture, Agricultural Aviation Section, in Melbourne, Victoria, Sept. 14, 1970.

in the western part of the state, and to work over the forests of eastern Victoria. These efforts were designed to dampen forests for fire prevention, fill mountain catchments, and bring needed precipitation enhancement to wheatlands.⁵⁰ The costs were paid for from the budget of the Agriculture Department and the Treasury determined how much was allocated for the weather modification work.⁵¹

In 1971 the Victorian government elected not to engage in rain-making operations. No authorities for weather modification were issued.⁵² The impact of this decision plus the statutory limitation of seeding to an agent or entity of the Agriculture Department has been to stop anyone from seeding clouds to enhance rainfall in the state. In 1971 Victoria has in effect copied the Maryland ban on weather modification.⁵³

The statute refers in section 3 to some of the reasons for which an authority may be issued. It speaks of "improving primary production either generally or locally," "reducing fire-danger in a forest," and "improving water storages."⁵⁴ These are the purposes for which authorities in the past have been issued. The statute additionally allows weather modification "for any other sufficient purpose."⁵⁵ Economic studies in the United States indicate that precipitation enhancement can yield great financial benefits by improvement of rainfall conditions, particularly in good weather years.⁵⁶ Authorization of projects which are well designed and carried out can bring about the benefits the law seeks.

50. Interview with Ian Searles and John Wylie, Cloud Seeding Officers, Victoria Department of Agriculture, Agricultural Aviation Section, in Horsham, Victoria, Nov. 18, 1970.

51. Interview with Rod Kefford, Principal Executive Officer, Victoria Department of Agriculture, Agricultural Aviation Section, in Melbourne, Victoria, Sept. 14, 1970.

52. Interview with J. P. Bearham, Victoria Department of Agriculture, in Canberra, Australia, Sept. 8, 1971.

53. MD. ANN. CODE art. 66C, § 110A (Supp. 1970).

54. Act § 3.

55. *Id.*

56. See, e.g., CHANGNON AND HUFF, EVALUATION OF POTENTIAL BENEFITS OF WEATHER MODIFICATION ON AGRICULTURE (Report to Office of Atmospheric Water Resources, 1971); CRUTCHFIELD, *Economic Evaluation of Weather Modification*, in WEATHER MODIFICATION: SCIENCE AND PUBLIC POLICY 105 (Fleagle ed. 1969); CRUTCHFIELD & SEWELL, *Economic Aspects of Human Adjustment to Weather and Climate*, in HUMAN DIMENSIONS OF THE ATMOSPHERE 59 (Sewell ed. 1968). For a general examination of the relationship of the social sciences to cloud seeding see HUMAN DIMENSIONS OF WEATHER MODIFICATIONS (Sewell ed. 1966).

Under Regulation 4 "every authority issued by the Minister shall be in the form or to the effect of the form of the First Schedule."⁵⁷ That appendage to the regulations sets forth the specifics of the format that is used. The authorities are numbered; they are addressed to the authorized body (the Aviation Section of the Department of Agriculture); they grant power to carry out operations in a specified area, stipulate the purpose for the undertaking, list any conditions, limitations or restrictions, and indicate the duration of time covered by the document.⁵⁸

The originals of each authority are retained by the Aviation Section in an office safe. By virtue of section 5(3) of the statute, copies of authorities are forwarded by the Department of Agriculture to the Minister of Water Supply, the Minister of Forests, and the Minister for Local Government.⁵⁹ Thus, not only the cloud seeding agency but also interested government officials and departments are aware of the scope of activities permitted.

Any authority "may at any time by the Minister be revoked or varied by notice in writing to the authorized officer or body."⁶⁰ Rule 5(b) says that "due account shall be taken during the currency of any authority of the interests of persons who may suffer damage from rain hail sleet snow ice fog or mist in specific areas at particular times of the year."⁶¹ A review committee has been established within the Department of Agriculture to assist the Minister in determining when operations should be modified or halted. It is composed of specialists in various fields of agriculture who are employed by the department and who are in contact with its district officers throughout the state.⁶² This provides a channel for handling requests to terminate or suspend seeding that might be made by persons adversely affected by rain-making. The Agricultural Aviation Section, however, has set

57. Rules § 4.

58. *See id.*, First Schedule.

59. Act § 5 (3).

60. Act § 5(1) (c).

61. Rules § 5(b).

62. Interview with Rod Kefford, Principal Executive Officer, Victoria Department of Agriculture, Agricultural Aviation Section, in Melbourne, Victoria, Sept. 14, 1970.

up its seeding program so as to minimize any potential harm and has voluntarily suspended seeding to avoid possible injuries. The review committee has not needed to act formally, although members of it have taken information to the Aviation Section which has guided it in carrying out its mandates.⁶³

When an authority has been issued at the request of some department other than the Department of Agriculture, the law requires that the Minister of Agriculture consult with the minister of the other department prior to revocation or variation of such an authority.⁶⁴ In such a case, neither the review committee nor the Aviation Section can shut down or alter the operation on their own.

There is recognition in the statute that cloud seeding in one state may produce a meteorological change in another state. Portions of New South Wales are downwind of Victoria and can be affected by Victorian seeding. Section 8 provides:

At the request of the Minister of an adjoining State administering any Act corresponding with this Act the Minister may authorize rain-making operations to be carried out in Victoria to promote rainfall in the adjoining State.⁶⁵

Because no other Australian state has enacted legislation, this provision has had no effect.

Cloud seeding officers operating in western Victoria have asserted that their chances of improving rainfall in the farming areas they wish to benefit would be increased, if they could operate just over the state line in South Australia.⁶⁶ The Rain-making Control Act does not address itself to that question. No mechanism is set up whereby officers from Victoria can seek approval from whomever in South Australia could permit operations to proceed.

Runoff from precipitation induced by cloud seeding over Victoria may enter the Murray River system. That river is for many miles the boundary between Victoria and New South

63. *Id.*

64. Act § 6.

65. Act § 8.

66. Interview with Ian Searles and John Wylie, Cloud Seeding Officers, Victoria Department of Agriculture, Agricultural Aviation Section, in Horsham, Victoria, Nov. 18, 1970.

Wales, and it passes through South Australia. Allocation of its waters has been the subject of recurring political battles among the states involved and with the federal government.⁶⁷ The Murray River Waters Agreement of 1941 with subsequent amendments empowers the interstate Murray River Commission to supervise works on the river and allocates its flow among the states.⁶⁸ Alterations in streamflow attributable to weather modification activities are of course not covered by the agreement. Neither does the Rain-making Control Act make reference to such changes.

Both the statute and the regulations are made applicable only to "rain-making operations."⁶⁹ This phrase is defined only to include "seeding or nucleating of clouds by artificial means from a manned aircraft."⁷⁰ Other methods of cloud seeding are not covered. Although all rain-making in Australia has been from aircraft, in the United States there has been extensive use of ground-based generators. The problem with their use has been getting the materials into the portions of the clouds which should be treated to bring about the most efficacious results. But where convective currents carry the silver iodide particles into the right place or where generators at high elevations are either in the clouds to be seeded or in the path of orographically induced currents, use of ground generators is less expensive and safer than use of manned aircraft.⁷¹ Ground generators would probably not be effective in Victoria; but should someone care to try to seed in that fashion, the law does not cover him. He would be exempt from the permit requirement.

Hail suppression efforts in Russia have relied upon artillery as a delivery system for the nucleating agent.⁷² Nothing in Victoria's statute would require artillerymen to obtain an authority before firing away.

67. The disputes and decisions over the Murray are outlined in CLARK, AUSTRALIAN WATER LAW: AN HISTORICAL AND ANALYTICAL BACKGROUND 272-453 (1971).

68. *Id.* at 406-17.

69. *See, e.g.*, Act § 3; Rules § 5(a).

70. Act § 2; Rules § 3.

71. For hints on aircraft safety see FIFTH COURSE OF INSTRUCTION IN CLOUD-SEEDING TECHNIQUES 23e (1970).

72. BATTAN, HARVESTING THE CLOUDS: ADVANCES IN WEATHER MODIFICATION 95-97 (1969).

Orchardists in Victoria have used anti-hail rockets in an effort to comfort themselves with the feeling that they are doing something about hail losses. Black powder rockets, with or without silver iodide, are inexpensive and bring about a mighty psychological boom. They do not, however, have the range to reach areas where meteorologists believe hail storms might be influenced. But the practice is comforting and does no harm.⁷³ Its continuation is not jeopardized by the Rain-making Control Act. Indeed, the definition of "rain-making operation" was intended to exclude the fruit farmers' efforts from control by the government.⁷⁴

The term "rain-making" itself does not seem to cover certain weather modification activities employed in the United States—snow-making, fog suppression, lightning suppression, and severe storm modification.⁷⁵ But many projects aimed at those types of atmospheric environment improvement do in fact rely upon "seeding or nucleating of clouds by artificial means from a manned aircraft." There has been no history of similar projects in Victoria, and the likelihood is that there will be none in the future because the need for them is slight.⁷⁶ Nevertheless, by virtue of the definitions provision in the statute, they might be considered "rain-making" and subject to the permit requirement should they be attempted.

Persons carrying out rain-making operations in Victoria which are not authorized under the statute and covered by it are guilty of an offense. Section 9 sets the penalty at \$1,000⁷⁷ or imprisonment for twelve months.⁷⁸ The following section states that a certificate from the Minister that any specific rain-making operations were not authorized shall be conclusive evidence.⁷⁹ The format of such a certificate is

73. Use of anti-hail rockets is an Italian innovation. *Id.* at 90-91.

74. Interview with A. L. Bateman, Legal Officer, Victoria Law Department, in Melbourne, Victoria, Sept. 14, 1970.

75. For a brief summary listing and evaluating the different types of weather modification efforts in the United States, see BATTAN, *The Scientific Aspects of Weather Modification*, in CONTROLLING THE WEATHER: A STUDY OF LAW AND REGULATORY PROCESSES 33-45 (Taubenfeld ed. 1970).

76. Interview with E. E. Adderley, CSIRO Radiophysics Division, in Epping, New South Wales, Oct. 26, 1970.

77. This would be roughly \$1,150 in American currency.

78. Act § 9.

79. Act § 10.

set forth in the regulations.⁸⁰ This device is intended to facilitate conviction upon trial of any offender.

There have been no incidents in Victoria of unlawful cloud seeding. Indeed, there are no cases at all in Australia on weather modification⁸¹ and only criminal action reported elsewhere.⁸²

As well as the criminal law, there is an administrative device available to discourage would-be unauthorized rain-makers. Under section 11 of the law the Minister may issue an order requiring the person or body to discontinue or refrain from commencing the activities.⁸³ The format for an order is provided in the regulations. It is a simple administrative cease and desist order.⁸⁴ Failure to comply with the terms of an order

shall in addition to any penalty to which he is liable under section 9 [make a person] liable to a penalty of not more than \$1,000 for every day upon which he continues to carry out rain-making operations in contravention of the order.⁸⁵

American statutes for the most part make illegal cloud seeding a criminal offense.⁸⁶ There is, however, a reluctance to enforce them. For example, during the summer of 1971 an unlicensed weather modifier operated in Texas in defiance of the law of that state and the provisions of its statute. When the Texas Water Development Board, the agency administering the law, approached the modifier, he defied them to have him jailed. The publicity from his trial would have given him extensive free advertising—something he was an-

80. Rules § 7, Second Schedule.

81. The nearest that anyone has come to making a weather modification-related claim was a New South Wales farmer who sought compensation for the loss of a cow that had perished from consuming part of a meteorological balloon and its package of instruments. They had been sent aloft from Cobar, New South Wales, where the state Department of Agriculture operates a cloud seeding project and relies on weather information received from such instruments. The claim was rejected by the crown solicitor.

82. *Township of Ayr v. Fulk*, No. 53 (C.P., Fulton County, Pa., Feb. 28, 1968). Early in this century there was a criminal case from Tasmania involving weather recording equipment. The defendant, who had urinated in a rain gauge while under the influence, was prosecuted for "committing a nuisance in a public convenience."

83. Act §§ 11(1)-(2).

84. Rules § 7, Third Schedule.

85. Act § 11(3).

86. See DAVIS, LEGAL GUIDELINES FOR ATMOSPHERIC WATER RESOURCES MANAGEMENT § 2.3 (Report to Bureau of Reclamation, 1968).

xious to have and the commission was just as anxious to avoid.⁸⁷ Texas has amended its law to permit the agency to get injunctive enforcement of the licensing requirement by going to court.⁸⁸ In Victoria the Minister can issue the order himself, and it is very expensive to ignore him, much more costly than the publicity value of a trial.

OPERATIONAL CONDITIONS

The regulations stipulate that authorized operations should be carried out in accordance with the techniques laid down by CSIRO, from aircraft fitted with CSIRO-approved seeding equipment, and by cloud seeding officers.⁸⁹ The Radio-physics Division of CSIRO has run five courses of instruction in cloud seeding techniques over the past decade.⁹⁰ Cloud seeding officers, as well as administrators, have attended these courses from Victoria, other Australian states, and abroad. The broad range of instruction includes explanation of the techniques developed by the Division for seeding. Visits in the field from CSIRO officers are also very useful in imparting information on appropriate seeding methods.

Victoria has used leased aircraft and manned them with pilots employed by the aircraft owner and a cloud seeding officer hired by the state. The cloud seeding officer acts as navigator and directs the pilot on the course to follow. The cloud seeding officer also operates the seeding equipment. That equipment and the silver iodide are obtained from CSIRO, which makes the generators, assembles the tanks, pumps, and gauges used inside the plane, and purchases larger quantities of silver iodide than any state would need and thus gets a better price.⁹¹ Such pooling of experience and resources is one of the reasons why Australia, a nation with a relatively small population, has been one of the leaders in weather modification work in the world.

87. Interview with John Carr, Texas Water Development Board, in Norman, Okla., Oct. 22, 1971.

88. Ch. 58, § 14.112, [1971] Texas Session Laws.

89. Rules § 5 (a).

90. These courses have been given in 1965, 1966, 1967, 1968, and 1970. Written materials have been made available to attendees.

91. Interview with Ian Searles and John Wylie, Cloud Seeding Officers, Victoria Department of Agriculture, Agricultural Aviation Section, in Horsham, Victoria, Nov. 18, 1970.

There has been trouble in other countries with uninformed and inexperienced persons conducting weather modification operations. In their blissful ignorance they have offered to "move clouds today" and "try mountains tomorrow."⁹² That problem has been avoided in Victoria. Personnel already employed by the Department of Agriculture in other capacities have been used exclusively for cloud seeding officers. They are given CSIRO instruction and on-the-job training. When they acquire the required degree of proficiency, a letter from the Radiophysics Division to that effect is placed in their personnel file. Their skills are tested by an inspection from a senior CSIRO cloud seeding officer before the Division certifies their competency.⁹³

This system amounts to a type of professional licensing. It protects the public from incompetents and from careless cloud seeders. It also aids the cloud seeding officer by giving him a record of his proficiency. When Victoria decided to suspend seeding during 1971, the cloud seeding officers then employed could have returned to their original jobs with the Department of Agriculture. Two of them, however, wished to remain in the weather modification field. They, along with over three hundred other applicants, replied to advertisements by the Tasmanian Hydroelectric Commission to fill two cloud seeding officer positions that opened up in 1971 as the result of the Commission's decision to move from a CSIRO-operated experiment in Tasmania to a cooperative CSIRO-Commission effort. The two Victorians got the positions. Their files demonstrated that they were the best qualified professionals to do the job.⁹⁴

Chartering aircraft for rain-making operations is covered by Part IV of the regulations. Tenders are called for by newspaper advertisements and by notification to all aerial opera-

92. Stories circulate of pilots who, upon reading of the use of dry ice in weather modification work in the late 1940's and early 1950's, tried their hand at the game by dumping out large blocks of dry ice. They did not alter clouds by that technique; but some barns allegedly were changed for the worse.

93. Interview with Arthur Tapp, CSIRO Radiophysics Division, in Epping, New South Wales, Oct. 26, 1970.

94. Interviews with Ian Searles and John Wylie, Cloud Seeding Officers, Tasmania Hydroelectric Commission, in Canberra, Australia, Sept. 8, 1971; Interview with Brian Watson, Tasmania Hydroelectric Commission, in Canberra, Australia, Sept. 8, 1971.

tors known to the Department of Agriculture to charter aircraft suitable for rain-making operations. Pilots employed by the charterer in cloud seeding work must hold a commercial pilot's license with first class instrument rating issued by the Commonwealth Department of Civil Aviation and have had at least a thousand hours of flying experience, including not less than a hundred hours cloud flying experience under instrument flying conditions. A statement to this effect is made by the aerial operator in his tender. The State Tender Board receives the recommendation of the Minister of Agriculture and may accept a particular tender or reject them all. It is not bound to accept the lowest tender.⁹⁵

This process can be time-consuming. Notification by mail must be made "not less than fourteen days before the closing date for tenders."⁹⁶ The process of Tender Board approval of recommendations from the Department of Agriculture and of issuance of the contract takes time too. Nothing is said of waiving tender requirements or of reducing the time it takes to comply with them if an emergency artificial nucleation project must be undertaken. During the time it takes to comply with the contracting provisions, forests which could have been dampened by artificially induced rain might be burned to the ground. An exception for emergencies should be written into the act and regulations.⁹⁷

Aircraft seeding flights are governed by the Air Navigation Regulations promulgated by the Commonwealth Department of Civil Aviation.⁹⁸ Where cloud seeding is performed from manned aircraft, governmental agencies with administrative powers to regulate the operation of airplanes can ef-

95. Rules § 10.

96. *Id.* at § 10(3) (a).

97. In California there are emergency sections dealing with fire fighting and drought. Various procedural requirements for licensing can be viewed by the regulatory agency under such circumstances. CAL. WATER CODE §§ 413, 413.5 (West 1956).

98. The original effort of the Commonwealth government to regulate civil aviation was ruled unconstitutional in *Ex parte Henry*, 55 Commw. L.R. 608 (Austl. 1936) as being beyond federal regulatory power. Following an unsuccessful effort to amend the Constitution, such regulatory power was granted to the Commonwealth by an agreement with the states whereby they undertook to enact legislation vesting in the federal government authority to promulgate such regulations and enforce them as federal law. Richardson, *Aviation Law in Australia*, 1 FED. L. REV. 242, 252 (1965).

fectively control weather modification.⁹⁹ Rule 120 of the Civil Aviation Regulations requires permission of the Director-General of the Department of Civil Aviation to carry dangerous goods. This includes things "which by reason of their nature are liable to endanger the safety of an aircraft."¹⁰⁰ Inflammables could constitute a safety hazard, and silver iodide in acetone is an inflammable substance. Hence, Department of Civil Aviation permission is required and obtained to engage in seeding clouds.¹⁰¹ Pilots are of course subject to all other aviation regulations in operation of their aircraft.

Since the dry ice seeding in 1947, CSIRO has been accumulating records on cloud seeding in Australia. When this information is considered along with historical data on weather from the Commonwealth Bureau of Meteorology¹⁰² and stream flows from the Murray River Commission and various state rivers and water supply commissions, it is possible to make analysis of the impact of cloud seeding on precipitation and runoff. Gauging inadequacies can distort the picture; gaps in seeding records can also blur it. It therefore is important in development and study of seeding techniques that records be maintained and that information from them be reported to CSIRO.

The state of Victoria, or any other operating agency, has added reasons for requiring its cloud seeding officers to keep records and to render reports based upon them. State officials who counsel with the Minister of Agriculture on issuance of authorities can do so intelligently only if they know what has been done previously and what its effects are. The review committee must also have information on seeding activities in order to determine whether to recommend termination of seeding or its suspension or alteration. Decisions based on factual information that can be obtained through use and analysis of reports are much more likely to be satisfactory than those reached without the light such reports can shed.

99. For example, cloud seeding in Israel and Kenya is to some extent governed by civil aviation rules.

100. AIR NAVIGATION REGULATIONS, RULE 120(2)(b)(i) (Austl.).

101. See FOURTH COURSE OF INSTRUCTION IN CLOUD-SEEDING TECHNIQUES 261-26m (1968).

102. See Meteorology Act § 6 (Austl. 1955).

A requirement of filling log books and keeping other records tends to discipline the cloud seeding officer's working patterns. His reports to the agency give his superiors a basis for keeping abreast of what he is doing.

The Rain-making Control Act authorizes the Minister to promulgate regulations "prescribing the information to be furnished by persons or bodies carrying out or assisting in rain-making operations under" the law.¹⁰³ Rule 9(1) requires cloud seeding officers to keep a log book of all flights. The log must show the flight route, meteorological data at the time of the flight, the duration of the flight and of all rain-making operations, and the location of such activities.¹⁰⁴ The form of the log book is set forth by the regulations.¹⁰⁵ Cloud seeding officers are supplied with printed blanks of such forms and use them in recording data.

Under Regulation 9(2), at the end of every week, cloud seeding officers must forward from their log books a report to the Aviation Section of the Department of Agriculture. This should inform that body about each individual operation in which the cloud seeding officer participated. These reports must be retained for a period of not less than a year.¹⁰⁶

The statute also requires reports from the agency, that is the Aviation Section, to the Minister upon his request or in accordance with the provisions of section 13(2). According to that part of the law where operations will be completed within two weeks of their commencement, there must be a report within two days after their completion. For operations of longer duration there must be weekly reporting with reports being filed by Wednesday of each week for the operations of the preceding week.¹⁰⁷ The Fourth Schedule of the regulations sets forth the form. The information that must be included is that which is taken from the logs, plus assessment and comments.¹⁰⁸

103. Act § 15(c).

104. Rules § 9(1).

105. Rules § 9, Fifth Schedule.

106. Rules § 9(2).

107. Act § 13(2).

108. Rules § 8, Fourth Schedule.

Nothing in the law requires officials of Victoria to report to CSIRO or any other central depository of information about weather modification activities in Australia. In the United States voluntary reporting has been a failure. At one time persons engaged in cloud seeding had to report to the National Science Foundation.¹⁰⁹ When the authority to demand such information was repealed, the Foundation attempted to maintain continuity in the records by asking for reports.¹¹⁰ Organizations holding government contracts and some other operators saw the wisdom of reporting; but the volume of information fell precipitously.¹¹¹

In Australia voluntary reporting to CSIRO is a success. Copies of the Victorian reports are supplied to that body.¹¹² The Australian states have a lot to gain from cooperation with CSIRO. Like contractors doing business with the federal government in the United States, it is effective diplomacy to report their activities.

LOSSES

Both the Rain-making Control Act and the regulations adopted under it recognize that some persons may suffer losses as the consequence of weather modification.¹¹³ The provisions of Rule 5(b) refer to "the interests of persons who may suffer damage from rain hail sleet snow ice fog or mist."¹¹⁴ In its report the interdepartmental investigatory committee, whose work set the stage for enactment of the law, also noted that there could be hazards from seeding operations. For example, they thought that an increase in rainfall sufficient to change the living conditions of grazing animals could also increase the number of diseased conditions in sheep

109. Act of July 11, 1958, Pub. L. No. 85-510, § 14(f) (1), 72 Stat. 353 (repealed 1968). The regulations in force under the statute were located at 45 C.F.R. §§ 635.1-7 (1968).

110. 33 FED. REG. 12654 (1968).

111. Interview with P. H. Wyckoff, National Science Foundation Program Director for Weather Modification, in Skyland, Va., Oct. 14, 1971.

112. Interview with Rod Kefford, Principal Executive Officer, Victoria Department of Agriculture, Agricultural Aviation Section, in Melbourne, Victoria, Sept. 14, 1970.

113. Act § 12; Rules § 5(b).

114. Rules § 5(b).

and cattle. Also harvesting some crops could be hampered by unwanted artificial precipitation.¹¹⁵

It is difficult to know the extent to which weather modification-induced changes in precipitation will bring about these and other unwanted effects. It is clear, though, that not everyone wants the same weather.¹¹⁶ Changes in the timing, location, intensity, and amount of precipitation can bring about runoff alterations.¹¹⁷ Even moderate shifts in weather can trigger at least some ecological¹¹⁸ and biological¹¹⁹ consequences. Altering the weather will have psychological, social, and economic results also.¹²⁰

Any claimant asserting a demand for compensation for an alleged injury from a cloud seeding project would have to establish to the satisfaction of someone that he really was injured and that there was some adequate relationship between the cloud seeding and his loss.¹²¹ No one has tried to do this in Victoria. In the United States, where they have tried, plaintiffs have been unsuccessful.¹²² When there is scientific disagreement over assessment of rain-making, it is not altogether surprising that this is the case. In any event some losses, like a washed out picnic, cannot readily be translated into legal "harm". And in other instances it would be very difficult to link a provable harm with the cloud seeding. Thus, the farmer with diseased sheep would not have an easy

115. COMMITTEE REPORT 12, *supra* note 26.

116. Australian sheep shearers will not shear wet sheep claiming that the practice results in rheumatic complaints. They have been known to vote the sheep "wet" even in drought conditions, particularly in the first week of shearing when stiff arms and backs demand a rest. A catchy folk song, "Another Fall of Rain", tells of the anxiety for the rain and joy when it comes. The boss, however, is not happy until after the rain "when his sheep they all are shorn."

117. Cf. CHAMBERLAIN & GRANT, *Weather Modification and its Relationship to Environment*, in MAN AND THE QUALITY OF HIS ENVIRONMENT 69 (Western Resources Conference 1967).

118. COOPER & JOLLY, *ECOLOGICAL EFFECTS OF WEATHER MODIFICATION: A PROBLEM ANALYSIS* (Report to Bureau of Reclamation, 1969). See also RANGO, *Possible Environmental Response to Weather Modification*, in PROCEEDINGS OF SECOND NAT'L CONF. ON WEATHER MODIFICATION 411 (1970).

119. Ecological Soc'y of America, Ad Hoc Weather Working Group, *Biological Aspects of Weather Modification*, 47 BULL. ECOL. SOC'Y AM. 39 (1966).

120. Some persons feel that it is somehow improper to seed clouds, since that involves changing nature. An Arizona rancher advancing that thesis was squelched by another Arizonian with the question: Isn't what you do to baby bulls contrary to nature, too?

121. See HIGGINS, *ELEMENTS OF TORTS IN AUSTRALIA* 216, 237 (1970).

122. See, e.g., *Adams v. California*, No. 10112 (Super. Ct. Sutter County, Cal., April 6, 1964); *Slutsky v. City of New York*, 197 Misc. 730, 97 N.Y.S.2d 238 (Sup. Ct. 1950).

time to demonstrate that the seeding project brought on additional rainfall in the area where his animals were located. And, even if he had needed rainfall data and could convince the court that the added precipitation was artificially induced, he would still have to prove the connection between that extra rain and the increase in the number of his sheep that became diseased.

The statute, regulations, and committee report all talk in terms of the kinds of things that happen when precipitation is increased. It is also possible to bring about a decrease in precipitation by cloud seeding. In fact in the United States there has been litigation based on such claims.¹²³ A recurring public relations problem of weather modifiers is the "robbing Peter to pay Paul" argument. This point was raised in debate on the act in the state parliament of Victoria by a member who asserted that "[i]f the clouds had been left untouched, they might have precipitated rain in mountainous areas."¹²⁴ Studies in the United States of such extended area effects from orographic cloud seeding indicate that the usual downwind effect is an increase in precipitation.¹²⁵ Not much work, however, has been done on non-target area effects from seeding of convective clouds. It is possible that they too might show downwind increases.¹²⁶ The explanation for these increases (or at least much slighter decreases in moisture available downwind) is based upon two facts. First, clouds are very inefficient precipitators with only something like ten percent of the moisture in a storm reaching the precipitation stage. Assuming an increase of twenty percent from artificial nucleation, air having a moisture index of one hundred would move downwind with an index of ninety due to natural precipitation and an index of eighty-eight where it had been treated. The difference is slight and can be more than compen-

123. See, e.g., Penn. Natural Weather Ass'n v. Blue Ridge Weather Modification Ass'n, 44 Pa. D. & C. 2d 749 (1968); Southwest Weather Res., Inc. v. Rounsaville, 320 S.W.2d 211 (Tex. Civ. App. 1958) and Southwest Weather Res., Inc. v. Duncan, 319 S.W.2d 940 (Tex. Civ. App. 1958), both *aff'd sub nom.* Southwest Weather Res., Inc. v. Jones, 160 Tex. 104, 327 S.W.2d 417 (1959).

124. 1967 PARL. DEB. 1416 (Vict.).

125. ELLIOTT, BROWN & GRANT, TRANSACTION OF SEMINAR ON EXTENDED AREA EFFECTS OF CLOUD SEEDING (Feb. 1971).

126. Interview with Ian Searles and John Wylie, Cloud Seeding Officers, Victoria Department of Agriculture, Agricultural Aviation Section, in Horsham, Victoria, Nov. 18, 1970.

sated for by seeding downwind.¹²⁷ The second fact is that the introduction of silver iodide into the clouds not only changes the microphysics of droplets within them, but also alters the dynamics of the clouds themselves. This can have a positive impact outside the target area.¹²⁸

Improper seeding of clouds can, though, bring about a decrease in precipitation from them. According to the United States Bureau of Reclamation:

Some adolescent clouds, with vigorous updrafts, will grow naturally into large clouds. Their precipitation efficiency may be *decreased* with indiscriminate seeding, causing the clouds to blow much of their water content out of the top where it appears as a large cirrus cloud shield.¹²⁹

So, there can be losses which are brought on by seeding-induced rainfall decreases.

During the ages before the flight of manned aircraft, no particular harm came from asserting, as Lord Coke did, that a man's land extends from Hell to Heaven.¹³⁰ There is a famous Tasmanian case, *Davies v. Bennison*,¹³¹ in which the defendant fired a bullet from a rifle and killed the plaintiff's cat, which was on a shed on the adjoining property occupied by the plaintiff. On the issue of trespass for the flight of the bullet, the court ruled that there had indeed been a tort; but it questioned just how high the owner's rights could extend into the air space above his land. According to the judge:

It seems . . . that the only real difficulty is in saying (what . . . need not [be said] here), viz., how far the rights of a landowner '*ad coelum*' will have to be reduced to permit the free use of beneficial inventions, such as flying machines, etc.¹³²

127. KAHAN, *Weather Modification Effects on Man's Environment*, in MAN AND THE QUALITY OF HIS ENVIRONMENT 81, 87-88 (Western Resources Conf. 1967).

128. Discussion at Weather Modification Ass'n Meeting, in Norman, Okla., Oct. 21, 1971.

129. BUREAU OF RECLAMATION, PROJECT SKYWATER: A PRECIPITATION MANAGEMENT PROGRAM 1 (1971).

130. COKE, INSTITUTES ch. 1, § 1(4) (a) (19th ed. 1832).

131. 22 Tas. L.R. 52 (1927).

132. *Id.* at 56. See also *Barker v. Adelaide*, S. Austl. L.R. 29 (1900).

The flight of cloud seeding officers over lands would seem to be within the spirit of the case. Mere entry into the airspace is not a trespass. Legislation and regulations governing aircraft movements in Australia add weight to the proposition that there is no liability.¹³³

Of course weather modifiers do more than merely enter the air space. They also dispense chemicals. The silver iodide particles eventually fall from the skies and come to rest on the land or become mixed with the precipitation. But weather modification techniques employ such small quantities of silver iodide in such diluted concentrations that there is difficulty in detecting silver in rainwater samples taken from seeded areas. Such samples have been taken from Tasmanian experiments and shipped to the United States for analysis by a former CSIRO officer, who now heads the Desert Research Institute in Nevada. It requires delicate neutron activation analysis to ascertain the amount of silver in the rainwater.¹³⁴ Given this state of affairs, no Victorian will be able to sustain a claim for losses alleged to have been inflicted by supposed silver pollution.

The most likely type of claimants to go to court in Victoria would be those persons asserting losses brought about by increased rainfall, flooding resulting from such an increase, or decreased rainfall. Assuming that such claimants could prove they suffered injuries which were caused by weather modification activities, it would also be necessary for them to establish in court a liability theory. This could be done by showing that the cloud seeding officer was negligent—that his conduct fell below the standards of his profession.¹³⁵ Because of the mechanism built into the act for revoking or

133. Among other enactments, the Victorian Wrongs Act § 30 provides:

No action shall lie in respect of trespass or nuisance by reason only of the flight of an aircraft over any property at a height above the ground which having regard to the wind and weather and all the circumstances is reasonable, or the ordinary incidents of such flight, so long as the provisions of the Air Navigation Regulations are duly complied with.

This law would apply to the entry and overflight, but probably not to the unusual incident of the cloud seeding flight.

134. Warburton & Maher, *The Detection of Silver in Rainwater: Analysis of Precipitation Collected from Cloud-seeding Experiments*, 4 J. APPLIED METEOR. 560 (1965); see also DOUGLAS, *THE SILVER IODIDE GENERATOR AND PUBLIC HEALTH* (1968).

135. See FLEMING, *TORTS* 120-21 (2d ed. 1961).

changing authorities when it appears to the review committee that harm will come from the seeding and the care with which the Aviation Section has planned operations, it is unlikely that any fault will be found with the project design. Because of the care taken in selection and training of cloud seeding officers and the supervision through the reporting system and visits from CSIRO officials and officers of the Aviation Section, it is also none too likely that there will be careless operations. But, if there are, the burden of proving negligence will be on the claimant. It is not a burden that will be often sustainable.¹³⁶

A more attractive approach to liability in Victoria would be the doctrine of *Rylands v. Fletcher*.¹³⁷ It applies when damage is caused by something escaping from the land if the activity in question constituted a non-natural use by the defendant of his land.¹³⁸ It has been applied to flooding cases where accumulations of water have escaped from the defendant's land and wrought harm to the plaintiff's.¹³⁹ Cloud seeding related floods might be regarded as having come from non-natural uses of the atmosphere. But, unless cloud seeding is carried out over state lands, the flood does not originate from the defendant's use of the air space over its land and the flood is not an escape of water from its land.¹⁴⁰

In Pennsylvania¹⁴¹ and West Virginia¹⁴² the weather modification control acts provide for liability for harm from droughts and floods caused by cloud seeding to be imposed by the regulatory commissions without stipulating that claimants must demonstrate any fault. There is strict liability in those jurisdictions, and it involves not merely

136. For a description of the use of expert witnesses to establish, among other things, standard of care facts see Mann, *The Yuba City Flood: A Case Study of Weather Modification Litigation*, 49 BULL. AM. METEOR. SOC'Y 690, 701-07 (1968).

137. L.R. 3 H.L. 330 (1868).

138. See HIGGINS, *supra* note 121, at 199-203.

139. *Charing Cross Electricity Supply Co. v. Hydraulic Power Co.*, [1914] 3 K.B. 772.

140. Statutory authority to act may be a defense even if the case should otherwise fit into the *Rylands* rule. See *Fullarton v. North Melbourne Elec. Tramway and Lighting Co., Ltd.*, 21 Commw. L.R. 181 (Austl. 1916). The defendants, however, must demonstrate that "their statutory power could not be exercised without causing the danger complained of." *Id.* at 192; see also *id.* at 187-88.

141. PA. STAT. tit. 3, § 1114 (Supp. 1970).

142. W. VA. CODE ANN. § 29-2B-13 (Supp. 1970).

the kind of flooding situation that the doctrine of *Rylands v. Fletcher* embraces, but also decrease in precipitation.

Another theory upon which liability might be founded for meteorological or hydrologic change caused by cloud seeding is nuisance. The High Court of Australia has insisted that the interest allegedly invaded in a nuisance claim must be a proprietary right recognized by law.¹⁴³ In the English case of *Walter v. Selfe*¹⁴⁴ there is a passage which has been frequently cited by Australian judges:¹⁴⁵

[O]ught this inconvenience to be considered in fact as more than fanciful, more than one of mere delicacy or fastidiousness, as an inconvenience materially interfering with the ordinary comfort physically of human existence, not merely according to elegant or dainty modes and habits of living, but according to plain and sober and simple notions among the English people?¹⁴⁶

In other words there must be a material interference with the plaintiff's enjoyment of his property.

Nuisance cases involve a balancing of interests between the defendant's rights in carrying on his activity and the impact they have on the plaintiff's use of his land.¹⁴⁷ It is possible that courts in Victoria might consider harmful effects of weather modification as constituting a nuisance.

The possibility of governmental liability was considered by the interdepartmental study committee in its recommendations to the legislature. It suggested that the law absolve the Crown from any liability for damages allegedly arising from cloud seeding and eliminate the possibility of a successful application for an injunction restraining the Crown from proceeding with weather modification.¹⁴⁸

Section 12(1) of the Rain-making Control Act grants an immunity from liability to the Minister, the body given an

143. *Victoria Park Racing and Recreation Grounds v. Taylor*, 58 Commw. L.R. 479 (Austl. 1937).

144. 64 Eng. Rep. 849 (1851).

145. See, e.g., *Haddon v. Lynch*, Vict. L.R. 230 (1911).

146. *Walter v. Selfe*, *supra* note 144, at 852.

147. See FLEMING, *supra* note 135, at 263-67.

148. COMMITTEE REPORT 19-20, *supra* note 26.

authority by him, and cloud seeding officers "in respect of any loss or damage caused by or arising out of the precipitation of rain hail sleet snow ice fog or mist in consequence of" authorized rain-making operations.¹⁴⁹ Subsection (2) extends a similar immunity to persons licensed in other states from liability for losses caused in Victoria.¹⁵⁰ As mentioned before, though, no other states have laws like the Rain-making Control Act.

Section 12 does not in terms purport to immunize the Crown, only officers of the government. However, the Victoria Crown Proceedings Act, section 23(1)(b), which gives permission for suit against the state for injuries caused by acts of its employees,¹⁵¹ has been interpreted as making the Crown liable only if the employee would have been liable.¹⁵² Since the Rain-making Control Act says the servants of the state are not liable, there is nothing left to build state liability upon.

The immunity provision also does not deal with equitable relief against government cloud seeding. Neither does it give any aid and comfort to an unlicensed seeder. It states:

Nothing in this Act shall be construed as depriving a person of any right of action that he might have apart from this Act in respect of or arising out of a rain-making operation that is not authorized under this Act.¹⁵³

During the debates on the bill in the state parliament, the question arose over what recourse persons would have who might be injured by licensed rain-making activities. The response was that they would be given state aid under laws relating to losses attributable to natural weather phenomena, such as droughts and floods.¹⁵⁴ These provisions do not afford a system of complete compensation but rather are in the realm of emergency relief measures.

149. Act § 12(1).

150. Act § 12(2).

151. Crown Proceedings Act § 23(1)(b) (Vict. 1958).

152. Hogg, *Victoria's Crown Proceedings Act*, 7 MELBOURNE U.L. REV. 342, 343-52 (1970).

153. Act § 14(2).

154. 1967 PARL. DEB. 606 (Vict.).

BENEFITS

In addition to making no provision for compensation of persons suffering losses from modification efforts, the statute also says nothing about allocation of additional water resources harvested by rain-making. The decision of the Minister of Agriculture, based upon the recommendations of the advisory committee, as to where to authorize seeding determines who will receive a portion of the benefits of cloud seeding. Owners of land upon which the added rain falls will get the advantage of the extra precipitation.

Under Victoria law, the State Rivers and Water Supply Commission controls the structures in the catchment areas over which the incremental precipitation is generated. That agency is empowered to distribute waters naturally occurring there.¹⁵⁵ Runoff from development of atmospheric water resources could be handled in the same manner.

It is important in allocation of benefits that all legitimate claimants be treated with equal consideration. During Arizona pioneer days a certain Henry Hooker acquired a shady reputation. At a cattlemen's meeting, one Dan Ming, who was no admirer of Hooker's was asked to utter a prayer for rain. Big Dan first had the men remove their hats, and then proceeded:

Oh Lord, I'm about to round you up for a good plain talking. Now, Lord, I ain't like those fellows who come bothering you every day. This is the first time I ever tackled you for anything, and if you will only grant this, I promise never to bother you again. We want rain, Good Lord, and we want it bad; we ask you to send us some. But if you can't or don't want to send us some, then for Christ's sake don't make it rain up around Hooker's or Leitch's ranges, but treat us all alike. Amen.¹⁵⁶

Victorian officials would do well to keep Big Dan's prayer in mind.

155. For a complete discussion of Victorian water legislation see CLARK, AUSTRALIAN WATER LAW: AN HISTORICAL AND ANALYTICAL BACKGROUND 454-557 (1971); see also Clark & Myers, *Vesting and Divesting: The Victorian Groundwater Act 1969*, 7 MELBOURNE U.L. REV. 237 (1969); Clark & Renard, *The Riparian Doctrine and Australian Legislation*, 7 MELBOURNE U.L. REV. 475 (1970).

156. GRANGER, WILL C. BARNES' ARIZONA PLACE NAMES 129-30 (1960).