Background Report 4

Economic impacts of cloud seeding

Hydro Tasmania and West Coast Council

April 2008

SGS Economics & Planning

This Report has been prepared on behalf of:

Hydro Tasmania

&

West Coast Council

This report has been prepared by:

SGS Economics and Planning Pty. Ltd.

ACN 007 437 729

119 Macquarie Street

Hobart 7000

phone: 03 6223 6006

fax: 03 6224 9009

email: sgstas@sgsep.com.au

web: www.sgsep.com.au

Table of Contents

Tables

Figures

Executive summary

This report is one of a number of reports providing supporting analysis to the main report **Impacts of cloud seeding – Socio-economic impact assessment on the West Coast community**. This report assesses the economic impact of cloud seeding on the community and Tasmania as a whole.

This report uses the assessment of the likely minimum and maximum effects of cloud seeding on rainfall in the West Coast, and based on information from the community and other sources, estimates the likely minimum and maximum economic impacts of this. The report looks at eleven potential sources of costs to the community and produces an assessment of the possible impact of cloud seeding on each. It considers both the costs incurred by normal frequent rainfall and the additional effects, where they exist, of cloud seeding on these. It also considers the economic impacts of perceptions of cloud seeding where relevant.

A recurring finding of the analysis is that, while naturally occurring, heavy, frequent rainfall creates substantial costs for West Coast residents, the impacts of cloud seeding are very limited as:

- seeding takes place only in part of the year (20 days per year over 8 months),
- affects a small part of the total West Coast area community, and
- has a modest effect on total rainfall in areas effected.

In particular, cloud seeding does not increase the number of days of rainfall and so is expected to have reduced effects on tourism and events.

The maximum impacts calculated are based on assuming the maximum impact of cloud seeding as an 8% increase in rainfall in affected areas during seeded months. This is much higher than Hydro Tasmania estimate when estimating benefits from cloud seeding. The high estimates for costs based on rainfall increases of 8% in the previous sections are almost certainly too high.

The minimum effect is based on much lower – and more realistic – effects of cloud seeding within the catchments and less effect in areas outside of the targeted catchments. Actual effects may be more than the minimum but are likely to be substantially less than the maximum effects estimated.

For Tasmania as a whole, cloud seeding offers a substantial cost benefit of at least $3.7 million. For West Coast residents, the benefits exceed the cost for the minimum impact estimate, but costs exceed the direct benefits to the West Coast community for the maximum impact estimate. Costs in this case are heavily dominated by the costs to the west coast mines (two thirds of all costs) rather than the broader community.

A summary of the findings are shown in the table below.

	Cloud seeding impact	Estimated max additional cost, normal rainfall	Cloud seeding additional cost	
Cost item			**Max**	**Min**
Construction	Minimal	$600,000	$15,000	$0
Maintenance	Minimal	$750,000	$10,000	$0
Building structures	None	ne		
Infrastructure	Some	$650,000	$21,000	$5,000
Deferred or cancelled activities	Minimal	$120,000	$6,000	$1,000
Lost tourism business	Minimal	$1,800,000	$12,500	$0
Mine operating costs	Significant	$16,000,000	$120,000	$10,000
Health and welfare	Negligible	ne		
Loss of residents to the region	None	ne		
Cleaning, Floods	Unlikely	ne		
Heating and lighting costs	None	ne		
All costs (rounded up)			**$185,000**	**$20,000**
Benefits of cloud seeding				
Additional power generated net of seeding costs	Direct			
- Statewide benefit			$8.0 million	$3.7 million
- Benefit to West Coast residents			$80,000	$38,000
Regular reliable water supply	Negligible	ne		
All calculated benefits				
- Statewide benefit			**$8.0 million**	**$3.7 million**
- Benefit to West Coast residents			**$80,000**	**$38,000**
Net benefit (rounded)				
- Statewide benefit			**$7 million**	**$3.7 million**
- Benefit to West Coast residents			**-$105,000**	**$18,000**

ne: not estimated as no additional effects from cloud seeding expected.

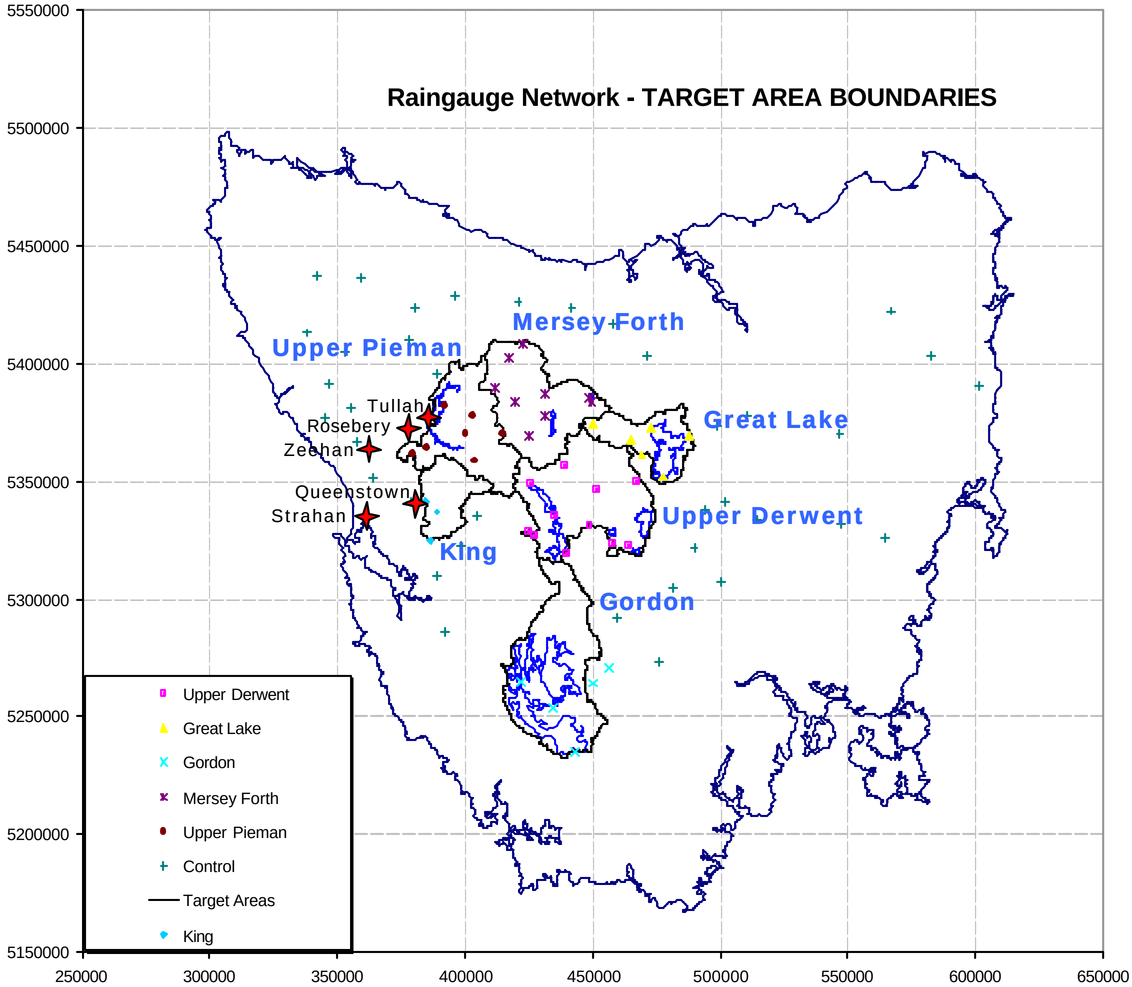
1 Introduction

1.1 Background

This report is one of a number of reports providing supporting analysis to the main report **Impacts of cloud seeding – Socio-economic impact assessment on the West Coast community**. This report assesses the economic impact of cloud seeding on the community and Tasmania as a whole.

Figure 1 shows the target areas and the main population centres of the West Coast.

Figure 1. Targeted cloud seeding catchment areas



Source: Hydro Tasmania

Hydro Tasmania's current annual cloud seeding program starts in early April and finishes in late November, running for up to eight months of the year. Cloud seeding may take place when the conditions are favourable, at any day of any week. Hydro reports an average of 20 days each year suitable for seeding, adding an estimated equivalent of an extra 12 megawatts of power of continuous output to its production capacity.

The catchment areas targeted by these cloud seeding activities are partly located in the West Coast Council LGA, but the target areas are predominantly located downwind from the West Coast communities. The river systems carry the water to the main storage lakes, including Lake Burbury, Macintosh, Pedder, Gordon, Rowallan, St. Clair, King William, Echo and Great Lake and to Macquarie Harbour and other river mouths.

Of the West Coast Council's major towns, at least Tullah and Rosebery are located within or in immediate vicinity to the target area. Together, they host around 25 percent of the West Coast Council's population. Queenstown is also reasonably close to the less frequently targeted King catchment.

The West Coast Council considers Hydro Tasmania's cloud seeding activity has negative effect on its community and economy.

Hydro Tasmania states that its cloud seeding activity is sufficiently targeted not to cause significant amounts of additional rain outside its target areas. The West Coast Council doubts this referring to research showing that cloud seeding can cause rain outside of the target areas.

The West Coast Council has requested the following statement be included:

> *Council's engagement with this process and the resulting reports has been designed to be constructive but should not in anyway be seen to limit any organization, business or individual's rights on the issue.*
>
> *Council contests some of the statements contained within the report due to the variability of weather patterns and the amount of scientific debate still occurring on the merits of cloud seeding and the persistence effect.*

1.2 Aim of this report

This report uses the assessment of the likely minimum and maximum effects of cloud seeding on rainfall in the West Coast and Tasmania as a whole, and based on information from the community and other sources on the kinds of effects arising from rainfall, estimates the likely minimum and maximum economic impacts of this. It considers both the costs incurred by normal frequent rainfall and the additional effects, where they exist, of cloud seeding on these. It also considers the economic impacts of *perceptions* of cloud seeding where relevant.

2 Economic impact assessment

2.1 Basis of assessment

The assessment of the economic impact of cloud seeding was based on field interviews with economic stakeholders to try to establish the kinds of effects on their economic activity, and where possible gain evidence about the scale of effects. Secondary data was then used to estimate the scale of these effects when applied across the entire West Coast LGA.

2.2 Economic stakeholder interviews

SGS interviewed twelve economic stakeholders on the West Coast:

- accommodation (3 operators),
- mining (3 operators),
- general food and retail (3 operators),
- local council (2 representatives),
- real estate (1 operator) and
- community development (1 representative).

The selection is a spread across the five townships of Strahan, Queenstown, Zeehan, Rosebery and Tullah. Of the seven business operators the interviewees were the owner/partner of the business. At both mines, we spoke to the environmental officer. We spoke to both the mayor and development officer at the West Coast Council.

Eight persons said that they do not have any direct outdoor related activities, however of these the accommodation providers take bookings for tour operators or cater for people on the West Coast for walks, fishing etc and also in general their businesses are affected by the outdoors activities of their clients. Both mines conduct underground operations and not directly outdoors, but they also have activities indirectly related to the outdoors such as preventing and managing water that gets into the mine. Two interviewees directly undertake outdoor activities (real estate trade and outdoor community projects), while the Council has some outdoor activities as part of its services including repairs and maintenance of infrastructure and community recreation. None of the accommodation or retail operators reported any outdoor activities, although as noted their visitors may well spend part of their visit in outdoor activities.

Seven organisations (all three accommodation providers, both council representatives, a retail outlet and real estate agent) said that **rainfall** causes visitors to cancel events or leave the area resulting in a general decrease in visitor numbers. Both mines stated that rainfall has a limited impact on their operations but water management is required due to rainfall. Two organisations said that rainfall limits or slows down work and activities, while one party reported no effect of rainfall on the organisation's activities, saying that locals are used to the rain.

The knowledge of the respondents of the nature of Hydro Tasmania's cloud seeding activity and perceptions about its general impact mirrored those of the general community such as depriving the east coast of rain, adding to the 'gloom effect' on the West Coast and concern about the health effects of the chemicals being used. Some were concerned about the accuracy of targeting, and the fact that the West Coast did not need any more rain. One quarter of respondents expressed some support for cloud seeding.

2.2.1 Impacts of rainfall and cloudseeding

On average respondents thought the effect of cloud seeding has 'some effect'. Few rated the effects as major, and one third expressed a lack of information on which to judge. None of the mines said that cloud seeding has a significant impact on rainfall.

Seven respondents, including all three accommodation providers, two shops, the Council and real estate agent, have said that rainfall and cloud seeding cause a reduction in visitors and customers at their business and in the area. These comments came from Strahan, Queenstown, Zeehan and Tullah.

One accommodation provider said that there was a reduction of 4-5% of visitors to his business due to cancellations because of rainfall. Similarly, two respondents said that they have had to cancel or postpone activities due to rainfall.

Four respondents, including a shop, accommodation provider and the Council, have said that rainfall increases maintenance and repair activities and cost. A specific example of this was in 2005 when the accommodation provider was undertaking renovations, and rainfall (which he believes was caused by cloud seeding) resulted in an increase of $30,000 in costs, not including potential lost revenue.

Two respondents, including a mine, said that there was either no impact or very little impact, while two mines said that impacts of rainfall on the business included pumping and treatment, and in one case, costs of excess capacity, pollution handling and processing difficulties.

When asked to rate the impact of rainfall and cloud seeding on their organisation, the average rating was 3.4, (1 = no impact, 5 = major impact) a rating that falls between 'some impact' and 'significant impact'. Two respondents that gave a '5' rating (major impact) said that this was during times when activities or building was planned, and would probably be about a 3 at other times, which would lower the average to 3. Including these responses of '5', six people (half of respondents) rated the impact at 4 or higher, while three rated the impact as 2 or less.

Three respondents (a mine, coffee shop and accommodation; from Rosebery and Queenstown) said that the impact of rainfall on their organisation was minor or negligible, while one respondent said the effects of cloud seeding and rainfall could not be separated. The Development Association and Council said that events and activities had to be cancelled or postponed, and similarly one respondent said that rainfall delays their activities hence increases costs. Also, two accommodation providers said there is 6 months of the year during which outdoor maintenance is restricted and one mentioned the major effects that were experienced during renovations/building. One Queenstown respondent said that the issue negates business expansion and affects development.

2.2.2 Response to rainfall effects

Four respondents, including the three accommodation providers, said they deal with the issue by adapting to it or simply coping with it. Three organisations (all in Queenstown) said that they do not take any action to mitigate rainfall and cloud seeding, two saying this was because the effect is minor and so action is not needed. One accommodation provider and a mine said that they do take some measures in regards to maintenance and capacity to help deal with the issue, but this is part of their normal maintenance and protection against rainfall in general.

Two organisations (the council and a store) said they conduct regular maintenance to mitigate the effects of cloud seeding and rainfall, while one respondent indicates certain business and maintenance activities were planned in summer to avoid the rain. Other actions included turning the issue into a positive - eg by having a rain festival, a threat of class action against Hydro Tasmania, or a cancellation list at an accommodation ensures there are still patrons even when some have cancelled because of the rain.

In spite of the effects of rainfall, eight respondents plan to continue to expand their business or organisation. Some plan to also develop in other adjacent business areas. The Council is experiencing and expecting a further boom and so intends allow for growth and plan accordingly. Council aims to attract miners and their families, and get developers to think and invest for the long-term. Three persons plan to sell the business and retire, not specifically due to the rain.

Six respondents said that their future plans will not be affected by cloud seeding, while two qualified this by saying that their plans will not be affected any more than usual. Of the six, three plan to leave or sell the business and these are not plans that would be affected by cloud seeding. Two organisations (a mine and the Council) stated that rainfall is an important consideration in new developments and expansion, while three organisations (among which an accommodation provider) said that people may be discouraged from coming to the area or using their services.

2.3 Natural rainfall and cloud seeding impacts

Some of the respondents correctly noted that it is not possible to distinguish between the effects of cloud seeding and the effects of rainfall, at least not without knowing the kind and amount of change to rainfall that cloud seeding causes. All of the effects cited as attributable to cloud seeding apply to rainfall in general – that is, heavy and frequent rain imposes some costs on the community. Furthermore, the strategies and many of the costs incurred in dealing with naturally frequent rainfall will need to be implemented whether or not cloud seeding takes place.

Costs increased by rainfall cited by economic stakeholders include:

- Increased building costs due to delays, deferred activity, the need for greater protection from rainfall etc.

- Increased maintenance costs due to constraints on timing of activities and direct impacts of water
- Additional building structures required by frequent rain (canopies, bus and other shelters etc.)
- Increased infrastructure costs (capital and maintenance) to deal with the effects of higher rainfall
- Deferred or cancelled activities, whether of a community nature or commercial
- Lost tourism business as visitors leave the area or are deterred from visiting
- Mine pumping costs due to greater water volumes

Other costs raised by the general community or identified by SGS include:

- Health and welfare costs, cited in the social impact interviews
- Loss of residents to the region (eg mining families choosing to live on the north west coast while workers commute)
- Additional cleaning costs and costs of floods
- Additional heating and lighting costs

While these costs have been identified by the community and SGS, there may be other unrecognised costs that are affected by rainfall. However, as they have not been flagged by respondents, we anticipate that they would be relatively minor compared the ones listed.

The next section looks at estimates of the impact of rainfall on each of these rainfall related costs for the West Coast community based on the insights derived from stakeholder interviews and secondary data on the scale of activity associated with various of those costs. For each it examines the way in which rainfall affects costs, and considers the likely effect, if any, of cloud seeding on increasing those costs.

The principal effect of cloud seeding is to make a rainy day rain somewhat more (up to 30% increase on a seeded day). There is no expected effect on the frequency of rainy days. Thus where costs arise from the frequency of rain, cloud seeding is unlikely to add to costs arising from natural rainfall.

The effects of cloud seeding are primarily in the largely uninhabited target areas, with a small but poorly quantified effect on areas adjacent to the target catchments. Further, cloud seeding only affects the West Coast during the seeding season, currently from April to November, with an average of 20 seeded days per year. For these reasons, where impacts of cloud seeding on top of natural rainfall do arise, they will add a relatively modest amount to the cost already incurred as a result of natural rainfall.

Given relatively limited information about the distribution of some activity across the region, most estimates of costs arising from rainfall and cloud seeding will be based on the relative population of each centre affected. In the case of mining, the location of major operating mines and their specific costs and expected impacts were assessed.

Where a cost increase from cloud seeding is expected, the total cost associated with natural rainfall is estimated as a base from which to estimate the extent of increases associated with cloud seeding. The additional effects of cloud seeding over the total West Coast area are then estimated using the estimated distribution and severity of effects as summarised in Table 1.

Table 1. Summary of expected cloud seeding effects

Community	Pop.	Context	Additional rainfall* Max	Additional rainfall* Min	Extreme rainfall
Queenstown	2117	Adjacent to King catchment	8%	0%	Once in 10 yrs max
Strahan	636	Distant from targets, receives King runoff	0%	0%	Once in 10 yrs max
Zeehan	846	Distant from targets, unaffected	0%	0%	none
Rosebery	1033	Adjacent to Upper Pieman catchment	8%	0%	Once in 2 yrs max
Tullah	195	On edge of Upper Pieman catchment	8%	4%	Once in 2 yrs max
Other WC	179	Various	4%	0%	unknown

* per seeded month

Source: SGS analysis of scientific data

The table includes a small number of people in unspecified locations expected to have a mix of experiences but generally to be less affected than those in the most affected areas. As can be seen from the table, under the maximum estimated impact, 3345 persons or two thirds of the West Coast population could have a **maximum** of 8% additional rainfall per **seeded month**. Alternatively, the minimum effect could be as low as 4% additional rainfall per seeded month on only 4% of the population.

Note that while seeding has infrequently been associated with extreme rainfall in some locations, this does not mean that it was the cause of the extreme rainfall. Further, there is only one cloud seeding day that occurred within one day of a flood event, however, the targeted catchment was distant from the flood, and no evidence supports cloud seeding as the cause.

2.3.1 Building costs

Rainfall effects

A number of respondents cited increased cost of building as a result of rain. Several also noted scheduling building activities to less rainy periods to avoid or minimise this. This will not always be practical: tourism operators will want to undertake building and upgrades in the non-peak tourist season which also tends to be wetter; large scale construction operations last through many seasons so the effects may not be totally avoided or even substantially reduced by scheduling.

Rainfall can increase building costs by:

- Requiring additional care and protection of water vulnerable building materials and incurring occasional losses due to water damage in spite of such care
- Additional site water runoff management provisions to protect against erosion, damage to temporary structures, and localised on and off-site flooding
- Restricting the number of operating days for some outside rain affected activities
- Interrupting work in progress, resulting in inefficient use of labour and equipment

- Extending construction timelines adding to finance costs

The extent of the impact will vary greatly according to the nature of the building activity.

Additional cloud seeding effects

The various sources of additional cost for building are each considered in the light of additional rainfall expected from cloud seeding:

• Requiring additional care an protection of water vulnerable building materials and incurring occasional losses in spite of such care	Required anyway, cloud seeding unlikely to affect
• Additional site water runoff management provisions to protect against erosion, damage to temporary structures, and localised on and off-site flooding	Some additional water volume may increase provision required – effect small
• Restricting the number of operating days for some outside rain affected activities	No increase in frequency of rain, unlikely to affect
• Interrupting work in progress, resulting in inefficient use of labour and equipment	No increase in frequency of rain, unlikely to affect
• Extending construction timelines adding to finance costs	No increase in frequency of rain, unlikely to affect

The only area where there is expected to be an additional cost with rising amounts of rain would be on site water management. However, on site water management primarily needs to deal with short severe events – retention times and volumes are generally small. Provision should design for the likely most severe event and cloud seeding is not associated with the most extreme events. Nonetheless we will assume there may be some additional cost arising from this source.

Costs associated with natural rainfall

The total amount of building activity on the West Coast varies substantially from year to year. The latest published regional profile shows the following activity on the West Coast. The average building activity for the most recently reported five year period is $2.7 million per year. However, the most recent West Coast Council Annual Report notes $5.8 million in building approvals for 2006/07.

Table 2. West Coast building activity

	2000	**2001**	**2002**	**2003**	**2004**	**Average**
			$m			
Value of total building	4.0	2.0	2.0	3.5	1.8	2.7

Source: ABS National Regional Profile, 2000 to 2004, ABS cat. no. 1379.0.55.001

Note that this may be affected by other factors:

- Approvals may overestimate construction costs as not all approved projects proceed.
- It may miss some construction activity as not all construction activity is subject to a building approval. The Council capital works budget is about $3.5 million per year, largely associated with construction expenditure.

Allowing for these factors and inter-year variability, $6 million per year is considered a reasonable indication of building activity in the area.

Construction cost guides provide some indication of the increase in costs in high rainfall areas. The Rawlinsons construction cost index for Queenstown is 120, that is, costs are about 20% higher in Queenstown than in Hobart. However, the majority of this additional cost is expected to arise from the relative isolation of Queenstown and the small scale of the local market. The small scale means that the local market cannot support the full scope of building trades based on local activity, and these need to come to the area over relatively long distances when required. Other very dry locations that are also distant from major centres (but have larger populations that the West Coast) also have construction indices of 120 or more relative to their state capital. Looking at high rainfall areas in North Queensland which are relatively large scale and so suffer less from isolation, but also subject to high rainfall, construction cost indices are of the order of 105 to 110. However, we note that rainfall in these areas is seasonal, and of quite different character to that in western Tasmania.

Allowing a premium for construction in high rainfall areas of 15%, which we consider to be a relatively high estimate for the impact of rainfall across the West Coast on construction costs, the total additional cost would be of the order of $900,000 per year.

Additional costs from cloud seeding

Respondents noted that project managers already attempt to schedule potentially affected building activity in the least rainy periods of the year, when cloud seeding does not take place. Thus any effect that may arise from cloud seeding on building activity would be less than proportional to the numbers of months within which cloud seeding occurs.

Overall it is unlikely that cloud seeding would add measurably to building costs in seasons already affected by frequent rainfall. As a maximum, costs may be increased by an additional 5% in affected areas and during cloud seeding seasons. Construction activity in affected seasons is likely to be about half of the activity for the year. The affected areas account for 67% of the population and it is assumed, an equivalent proportion of construction activity. The calculation of the maximum effect of cloud seeding is shown in the table below. More realistically there is no real effect of cloud seeding on building costs above those incurred by natural rainfall.

Additional construction cost due to rainfall, pa	$900,000
Affected population	67%
Proportion of cost increase in affected areas	5%
Proportion of activity over the year affected	50%
Potential maximum effect of cloud seeding	$15,000

2.3.2 Maintenance costs

Rainfall effects

Building maintenance costs were also frequently cited as being subject to increase. Maintenance costs may be higher if the original structure was not designed to standard. For some building structures, regular heavy rainfall may speed deterioration of the fabric requiring more frequent repair or renewal, particularly where maintenance is not sufficient to maintain the integrity of painted surfaces and operation of drainage systems (eg cleaning of guttering and trenches). Regular rain may make it difficult to schedule outside works or interrupt works in progress, making labour deployment less efficient.

Additional cloud seeding effects

As with construction costs, the costs of building maintenance arising from frequent natural rainfall are also unlikely to be measurably increased by the additional rainfall from cloud seeding. However, as a generous estimate we may allow that maintenance costs increase over and above that for normal rainfall by half of the amount of additional rain received, in affected areas during affected months.

Costs associated with natural rainfall

Maintenance costs can be estimated as a percentage of existing building fabric[1]. A broad estimate of this can be obtained from the property valuations for the LGA. In 2004, the total property valuation in the West Coast was $250 million. A high estimate of maintenance costs for buildings would be about 3% per year, or about $7.5 million. If maintenance costs were increased by 10% as a result of high rainfall, then this would imply rainfall increases total maintenance cost by about $720,000 per year. We believe this is a very high estimate. However such a high estimate can be justified in allowing for effects on non-building assets (garden structures, landscaping etc.)

We note that a large proportion of the assessed property value is likely to be in the mining industry. The mining industry also has a range of operating assets that are not classified as buildings for rating purposes and that these will have relatively higher maintenance costs than the 3% nominated for buildings. However, the mining respondents have not indicated additional costs of maintenance due to rainfall on operating equipment as a major cost, so this has not been assessed.

[1] Maintenance associated with infrastructure is considered separately below.

Additional costs from cloud seeding

Additional maintenance cost due to rainfall, pa	$750,000
Affected population	67%
Proportion of cost increase in affected areas = half of 8% increase in rainfall (max)	4%
Proportion of activity over the year affected	50%
Potential maximum effect of cloud seeding	$10,000

2.3.3 Provision of additional building features

Rainfall effects

High levels of rainfall may dictate that some facilities require additional sheltered areas to allow some semi-outdoor activity rather than remaining shut in to buildings during persistent wet weather. This could include awnings or canopies over play areas for schools and day care, shelters at outdoor event venues, etc.

Additional cloud seeding effects

As cloud seeding increases the intensity of rain on already rainy days, it is unlikely to affect the decision to add additional shelter structures that would have been provided to address naturally frequent rainfall. As cloud seeding does not cause the heaviest rainfall events, it is unlikely to change the design requirements of such structures.

The additional cost of cloud seeding on this cost of rainfall is considered to be $0.

2.3.4 Infrastructure costs

Rainfall effects

High rainfall imposes greater demand on storm water management, can lead to washouts and higher maintenance and replacement costs for roads and can lead to flooding. In principle, infrastructure should be designed to cope with peak events with a reasonable return frequency, eg a 1 in 100 year event. Where rainfall is high, this will require more demanding standards than in low rainfall areas, adding to infrastructure capital costs.

In some cases, costs can be reduced by good planning practices – restricting development in flood prone areas, ensuring appropriate storm water management when new buildings are developed etc. However, a legacy of past decisions often means a Council has to deal with what is there, however regrettable the results of past planning and development.

> *Primarily all infrastructures were originally developed by the mines, however since the 1980's this has progressively been transferred to Council. The age and design in particular of the water and sewerage infrastructure is such that even with a decreasing population the cost of providing the service continues to grow.*
>
> West Coast Council, General Manager Paul West, letter to the Grants Commission, 22 June 2000

The West Coast has a greater length of roads per capita than Tasmanian communities on average. This is not uncommon for rural local government areas. However, when the greater length is combined with higher costs, the burden becomes further increased.

In addition to local government roads, there are also state government roads in the area that may be subject to higher maintenance costs due to rainfall. However, these are all sealed roads and the total length is about half that managed by the Council.

It is arguable that the current level of infrastructure, storm water in particular, is not sufficient to meet the rainfall demands that occur at times. Equally, the Council with a declining population and correspondingly reduced financial assistance grants from the Commonwealth may not have the capacity to attain the required standards – hence maintenance costs are higher and the community experiences periodic flood events.

Extreme rainfall has indeed caused washouts and road closures with attendant delays and repair costs. In practice, these have mostly been on State government roads. A review of recorded events over the last five years suggests that there have been two major events resulting in serious landslides, one in 2004 and the most recent on 13 August, 2007 in which the Reece Dam Road near Tullah and the Murchison Highway near Rosebery were blocked and closed by landslides.

Additional cloud seeding effects

Cloud seeding is not associated with a significant proportion of the most extreme rainfall events, ie thunderstorms, nor is it associated with the most extreme of these and therefore would not affect the design capacity of infrastructure in the West Coast. If infrastructure has been designed for the maximum regularly naturally occurring events expected, cloud seeding would not have an impact on design specifications adopted.

Additional rainfall loads do have effects on the rate of deterioration of infrastructure, particularly infrastructure that is ageing or was inadequate to meet conditions in the first place. Additional rainfall volumes could make some direct contribution to the need for additional maintenance arising from land slippage, erosion and undercutting of roads and other structures, etc.

It is notable that the events of 13 August 2007 did not coincide with any cloud seeding. The closest cloud seeding event before that occurred on 4 August, 8 or 9 days before the storm. Also, that storm affected areas across the north of the state closing roads due to flooding, in areas where cloud seeding is not undertaken. The date of the 2004 event has not been established.

Costs associated with natural rainfall

While capital costs for some infrastructure in high rainfall areas can be expected to be higher than in low rainfall areas, we do not expect cloud seeding to further add to the specifications of that infrastructure and therefore add to capital costs. Additional construction costs for this infrastructure in high rainfall areas have been taken into account above.

Most additional costs from cloud seeding are likely to be associated with maintenance. This would be both in terms of the effect of delaying or adding to the cost of work being done, but also in direct damage causing loss to assets. Thus we propose to assume 20%, a higher impact on costs than used for construction cost increases.

Infrastructure maintenance costs for roads and bridges, water and sewerage vary but are of the order of $2-$2.5 million per year. We note that the amount spent may not fully equate to the amount that *should* be spent to fully maintain assets. It is not uncommon for a small rural council to fall behind in spending due to limits on available funds. Thus we will use the larger value of $2.5 million. In addition, we will allow for $750,000 expenditure by state government on their infrastructure, primarily roads, in the West Coast area.

If it is assumed that rainfall increases costs by 20%, then the impact of rainfall on additional maintenance costs would be $650,000. We believe this is a high estimate.

Additional costs from cloud seeding

We note that the additional rainfall affects about two thirds of the population, and infer that the distribution of affected infrastructure may be roughly proportional to the population. This is considered to be a conservative (ie relatively high) estimation of affected infrastructure, as much of the local government infrastructure is roads and some of these are more distant from the affected areas on average than the population.

The maximum additional rainfall caused by cloud seeding is estimated at maximum to be 8% in seeded months which are about 60% of the year. This roughly translates to about 5% additional rainfall over the year in the most affected areas.

The additional cost of infrastructure maintenance caused by rainfall was estimated to be $650,000. Taking all of the factors discussed into account, suggests that the **maximum** additional effect of cloud seeding would be as shown in the table below. The minimum effect is estimated to be of the order of one quarter of this, say $5,000.

Additional maintenance cost due to rainfall, pa	$650,000
Affected population/infrastructure	67%
Proportion of cost increase in affected areas, seeded months	8%
Proportion of activity over the year affected	60%
Potential maximum effect of cloud seeding (rounded up)	$21,000

2.3.5 Deferred cancelled or otherwise affected activities

Rainfall effects

Many respondents in the economic stakeholder, community stakeholder and general community surveys cited the cancellation of some outdoor community events and activities as an impact of rainfall and cloud seeding. There were notable exceptions: and outdoor tourism operation that proceeded even in rainy weather, the continuation of tennis matches in the rain, etc.

Many respondents also cited contingency planning – either an alternative indoor venue or activity, or other provision against rain. Some noted that the event such as a sporting match continued, but that the number of spectators is greatly reduced.

Responses suggest that the proportion of outdoor events actually cancelled is modest, from 0% for some events up to about 10%-20% for more susceptible ones. More outdoor events would be affected by reduced attendance, but here estimates were generally not provided.

Additional cloud seeding effects

As noted previously, cloud seeding does not increase the frequency of rain but increases the intensity of rain on already rainy days. Further its effects are greatest on days that would naturally be 'rainier'. It is quite possible that at times, the additional intensity may be the difference between proceeding or cancelling an outdoor event, or between an individual choosing to attend or stay at home (or undertake and indoor activity). However, given the information available, quantifying this is somewhat speculative.

In most instances we do not expect the effects of cloud seeding to have significant impacts on attendance over and above the effects arising from rainfall alone.

Costs associated with natural rainfall

SGS have not been able to compile a comprehensive list of outdoor community events and activities held on the West Coast over a year that have been affected by rainfall. The average number of days of rain per year varies from 176 in Zeehan to 198 at Queenstown[2]. Given the population, outdoor events that have been noted and broad indications of the level of community activity, it is expected that a maximum of 60 community outdoor events[3] per year, on average, are significantly affected by rainfall to the extent that they are cancelled or lose substantial patronage. We acknowledge that this estimate remains fairly speculative but we believe it is a very high estimate. We also note that this will vary substantially from year to year.

[2] BOM, period of available record varies.

[3] We note that this does not include private planned outdoor events and casual outdoor activities. We recognise that these will also be affected, but in general would be more easily accommodated indoors than some sporting or other outdoor community events.

It is very hard to determine the costs associated with rainfall at an event, whether due to diminished attendance or cancellation. If can vary tremendously with scale of the event. Costs may be substantial for events with a commercial element, but these are most likely to ensure some contingency planning to mitigate this. For events that are free to attend, the costs are unlikely to be monetary, at least in the short term, but potentially affect community engagement and participation.

We propose a notional $2,000 cost per affected event, say $10 per head for 200 persons as a proxy to get some sense of scale for the issue. Clearly this is an over estimate for many events and a substantial underestimate for a few. For 60 events this would amount to $120,000 per year.

Additional costs from cloud seeding

As noted earlier, cloud seeding will not result in more rainy days, but on average will produce 30% more rain on seeded days that would have occurred without seeding in affected areas.

Of the estimated 60 outdoor community events per year that may be affected by rainfall, assuming they are distributed according to population around the West Coast about two thirds will occur in locations potentially affected by cloud seeding (Rosebery, Tullah, or Queenstown). Also assuming that more affected events are in the seeded months (which are on average more likely to be rainy and therefore more likely to be the times when outdoor events are affected), we assume that three quarters occur in the seeding season. Together these assumptions would rather generously estimate that 30 events may be affected in areas potentially affected by cloud seeding in the seeding season.

However, the catchments adjacent to potentially affected areas were seeded on average only 6 times for the King catchment and 9 times for the Upper Pieman in the period from 1999 to 2007 and much less than that in most years[4].

To have an effect, the seeding would have to occur on the day of or just prior to an outdoor community event, and have a sufficient impact on rainfall to affect attendance or lead to cancellation. In the seeding months, more than half of all days are rainy in an average year, about 144 days in Queenstown and 139 in Rosebery. Thus seeding occurs on about 4% of rainy days in Queenstown and about 6% of rainy days in Rosebery and Tullah. It was assumed that seeded rainy days, when they occur, are three times as likely to lead to cancellation as unseeded rainy days, reflecting the fact that seeded days are more likely to be significantly rainy than unseeded days. However, that does not imply that the seeding caused the cancellation, only that they coincided.

The probability of a seeding event coinciding with a scheduled outdoor community event and resulting in cancellation was simulated using a stochastic model with random numbers determining the days on which rainfall occurred for 120 simulated years. Events were assumed to cluster at weekends, and averaged just over seven per week in the affected areas.

[4] If the heavily seeded years 2000 and 2001 are excluded, the average is 3 seeded days for the King catchment and 6 seeded days for the Upper Pieman.

Combining all of these considerations the modelling estimated that 3 of the 30 cancelled or affected outdoor community events would coincide with a cloud seeding day. That does not imply that the cloud seeding necessarily caused the cancellation. However, using the $2,000 per event measure, the maximum effect is likely to be about $6,000, our high estimate. It is possible that cloud seeding has substantially less effect than this, both because seeding may coincide with cancellation but not have caused it (it may have been cancelled anyway) and any events where seeding was the cause may have had a lower costs. Thus a lower bound estimate of impacts would be, say, $1,000.

2.3.6 Lost tourism business

Rainfall effects

Tourism operators report that rainfall can cause visitors to shorten their stay in the region or reduce the number of outdoor activities they undertake even if they remain in the area. A **reputation** for high rainfall may also reduce the number of visitors that plan to come in the first place, depending on the nature of experience they are seeking.

The effects are most likely to arise from the frequency of rain, rather than from modest changes in severity. While visitors accept periods of rain and can plan activities that are not greatly affected for a few days, persistent rain is more likely to discourage some, particularly if they have rain sensitive activities planned or limited time. One tourism operator estimates that 4%-5% of visitors may choose to shorten their stay due to persistent rain.

While rainfall can discourage outdoor and rain sensitive activities, it may even increase the use of indoor activities for those visitors that are in the region.

Some indication of the impact of rainfall on visitor numbers can be obtained by looking at changes in visitor nights on wetter and drier years. Data on numbers of rainy days for each year has not been provided, and total rainfall is used as a proxy. There is a general correlation between total rainfall and number of rainy days, although a few intense rainfall events can distort this relationship in some years. To the extent that cloud seeding affects intensity of rain more than frequency, it contributes to this distortion.

Figure 2 shows the trend in the number of visitors and visitors nights, indexed to 1999-2000, for West Coast and Tasmania, and displays the seasonally weighted relative rainfall. The rainfall 'index' is taken as the weighted sum of seasonal rainfall, with more weight given to January to March, the peak visitor season and the least to July to September. The weights reflected visitors number in each quarter. There is no clear trend in total visitor numbers or nights compared to rainfall for the period from 1999 to 2006.

As can be seen from Figure 2, visitor numbers to the West Coast roughly paralleled Tasmania's rising trend from 2001-2001 to 2003-2004, but fell behind in the years following. Visitor nights were more volatile.

Figure 2. Visitor numbers, nights and rainfall

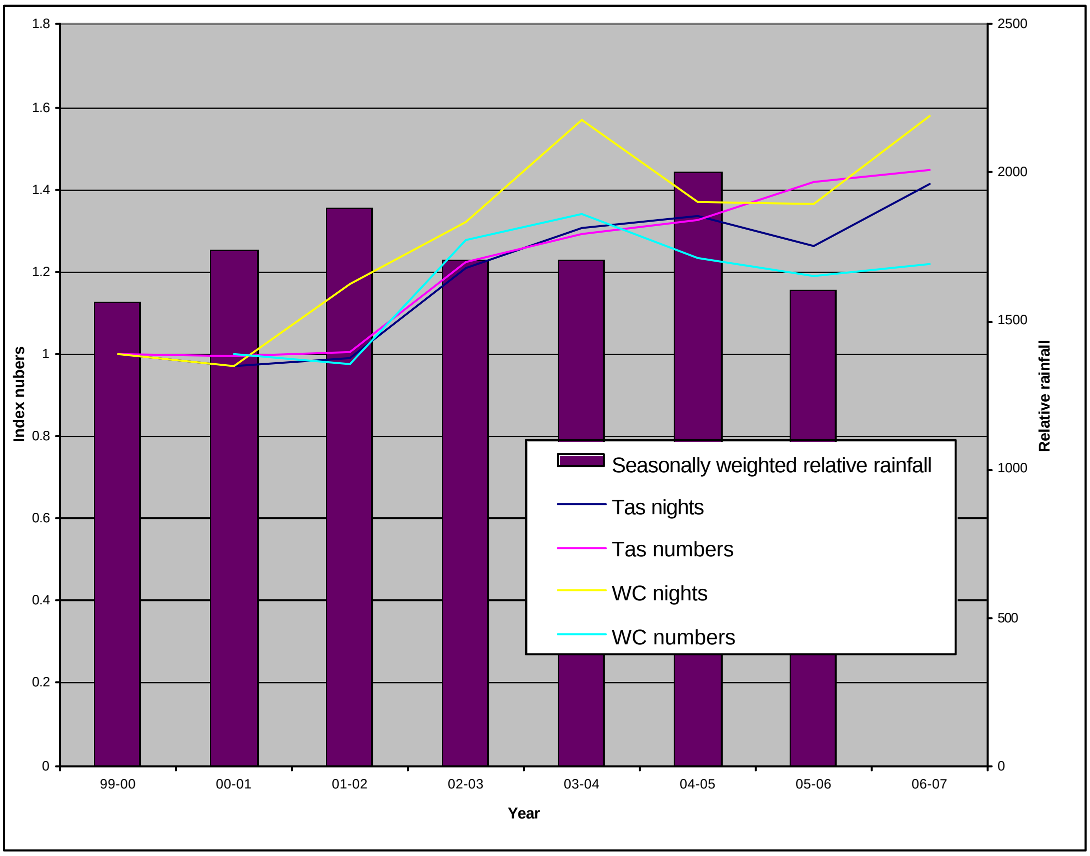
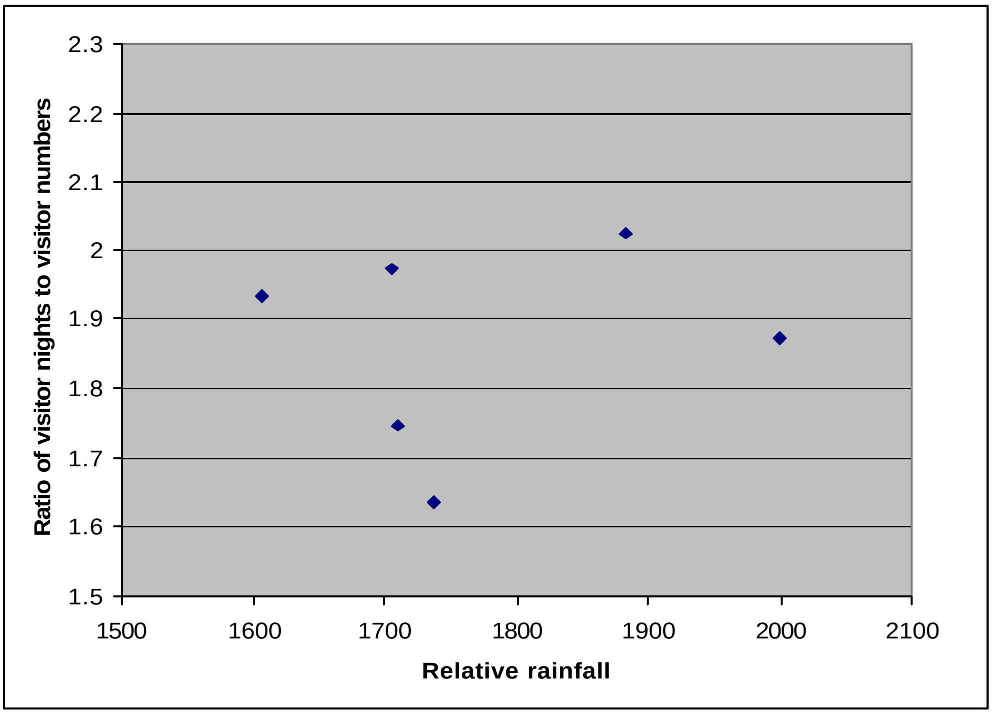


Figure 3. Ratio of visitor nights to visitor numbers compared to relative rainfall



SGS Economics & Planning

While statewide visitor night numbers tracked total numbers closely in most years, for the West Coast, visitor nights were up relative to visitor numbers in some years much more than others. However, there is no evident relationship between years with relatively higher or lower visitor nights and rainfall. This is clearer when looking at Figure 3, which compares the ratio of visitor nights to visitor numbers with the relative rainfall.

These charts suggest that the effects of rainfall, if present, are certainly much smaller than other influences on visitor numbers and nights. It could at best be seen as consistent with the comment by one operator that 4%-5% of visitors may shorten their stay, a small change relative to the over 50% variation over the period shown in the charts for visitor nights.

In this sense, while there may be some effect from rainfall from year to year, the effect appears to be far weaker than other factors. It is likely that the prime determinant of visitor numbers to the West Coast is the total number of visitors to the state. Beyond that, the attractions of the area, their appeal to the particular visitor profile coming to the state and the effectiveness of marketing these to visitors are likely to remain the primary determinants.

A perception of high levels of persistent rain may act as a deterrent to visitors coming to the area at all. Emphasising the rainy character by highlighting even potential impacts of cloud seeding may not be helpful in this.

Additional cloud seeding effects

The impact of year-to-year variation in rainfall on visitor numbers and nights is unclear, but not strong. As cloud seeding does not increase the number of rainy days, any additional impact is less likely. Even if there is an impact, the seeding season corresponds with the low season for visitation, with fewer than one third of all visits occurring during this time of the year. About 25% of visitors at this time of year are business visitors, who are less likely to be deterred by rainfall.

Costs associated with natural rainfall

If the effect on visitor numbers estimated by the tourism accommodation operator is valid, the impact can be estimated by looking at the total numbers of visitors and average spending per night. The total number of visitor nights in the year July 2006 to June 2007 reported by the Tasmanian Visitor Survey (TVS) was 196,000. If 5% of these were deterred from staying one night, this would correspond to about 10,000 visitors nights (rounded up). Estimated spending per visitor to the state is about $180 per night, for all expenses (TVS). Thus the implied loss due to rainfall may be $1.8 million if this estimate is correct. We believe this is a high estimate of the likely effects of rainfall on tourism spending, *for visitors that would have been attracted to the area anyway*.

Additional costs from cloud seeding

It is possible that a few visitors may be affected by the somewhat more intense rainfall, causing them to change their plans and leave the area sooner. It is likely to affect leisure visitors rather than visitors here for business. However, it would apply at most, only to those visiting during the seeding season (approximately 33% of all visitors, of which 25% are business visitors), and mostly in the towns that might be affected by cloud seeding. For visitors driving to other destinations through affected areas, there may also be some impact, but the proportion likely to be discouraged by driving through additional rain arising from cloud seeding (when it does happen) is not likely to be great, perhaps one third.

Queenstown, Tullah and Rosebery attract only about 25% of all visitors to the West Coast. However, they attract a higher proportion of business visitors, about 15% compared to 4% in Strahan[5]. During the winter, business visitors are likely to approach half of all visitors in the affected areas. However, most visitors to Strahan would have to drive through these towns, and may also be influenced by any heavier rainfall.

Additional, effects from cloud seeding would only occur on seeded days, as noted about 6% of rainy days (see discussion in last part of Section 2.3.5). Even then, not every seeded day would necessarily change a visitor's assessment of whether to stay or leave: they may have made the same choice with or without cloud seeding. Nonetheless we have assumed that all seeded days may influence some visitors to affected areas to leave where otherwise they would not have, and for those just driving through, about one third.

Taking all these factors into account suggest the potential additional effects from cloud seeding would be of the order of:

Lost visitor spending due to 'normal' rainfall, pa		$1,800,000
Affected visitor portions		
Share in seeded season		33%
Directly affected area:		
Share in potentially affected area	25%	
Share of leisure visitors	50%	
Number of seeded days affecting decisions	100%	12.5%
Total in affected area:		
Driving through affected area:		
Share driving through affected area	75%	
Share of leisure visitors	90%	
Number of seeded days affecting decisions	33%	
Total for driving through affected area		22%
Portion of rainy days seeded		6%
Potential maximum additional effect of cloud seeding (rounded up)		$12,500

A secondary effect that would clearly be far greater than this is the perception of the West Coast as a rainy location, particularly if regular publicity is given to the perception that cloud seeding makes it rain more often. If only 60 visitors that would have stayed one night each are deterred from coming at all (that is, 0.02% of all visitors), the cost is equal or greater than the maximum plausible direct effect of additional rainfall from cloud seeding.

[5] Tasmanian Visitor Survey 2006-07 Error in the estimates is likely to be high for the smaller towns but low for Strahan, which has much higher visitor numbers.

2.3.7 Mine operating costs

Rainfall effects

Some mining operations are subject to ground water seepage or surface water entry into mining areas. However, this varies substantially depending on the type of mine and history of development. Interviews were held with representatives of the Henty Gold Mine and with Copper Mines of Tasmania to discuss the economic impacts of rainfall and cloud seeding on their operations. A follow up call was made to the Zinifex Rosebery to assess rainfall impacts on their operations. Cost impacts are quite mine specific, and details have been obtained from three major mines.

The Henty Gold Mine is apparently not subject to significant rainfall infiltration and effects of rainfall are considered by those interviewed to be negligible on the mine. The tailings dam can be affected by rain but has been designed to cope with expected rainfall conditions.

The Copper Mines of Tasmania (CMT) copper mine is subject to infiltration of rainwater, with the volume of water pumped apparently proportional to rainfall. This has several effects on operations:

- This water must be pumped from the operational areas. The pumped water needs to be treated before discharge to streams. The larger the volume of water pumped, the greater the cost to the mine operator.
- If the quantity of infiltration exceeds capacity of the system, lower levels of the mine may be flooded and some polluted water may be discharged to streams
- Ores may become harder to handle – 'sticky dirt'

The Zinifex mine at Rosebery is an underground zinc, lead, gold silver and copper mine. Mine management here stated that rainfall effects are primarily on surface water management as they also handle the town's storm water and sewage treatment. Here pumping costs are proportional to rainfall. Rainfall was not considered to affect mining operations, which are mostly underground. While there are some underground pumping costs, they are affected by groundwater conditions and not directly related to rainfall. Rainfall can also affect retention times of water in the tailings dam and in periods of very high rainfall may have adverse effects on water quality if retention times fall too much.

Another mining and related operation potentially affected by cloud seeding is Bluestone Mines (Metals X) underground tin mining operations at Renison Bell. These ceased in October 2005 but are planning to reopen in early 2008 as operations are expected to be viable with rising prices and the additional scale in conjunction with new open pit mining operations at Mt Bischoff (in Waratah Wynyard local government area). This includes plans to reprocess tailings from previous mining operations. As the Bluestone Mines Renison Bell operation is not currently in operation, information was not sought on operating costs at this time.

The operations of Intec Hellyer Metals re-treatment of tailings at the former Hellyer mine to produce zinc concentrate in neighbouring Waratah Wynyard local government area are also close to the Upper Pieman target area and may be affected by cloud seeding. However specific costs of rainfall for this mine have not been pursued as it is outside of the study area.

Other mining operations are far enough from the target areas that cloud seeding should not affect them.

Additional cloud seeding effects

Cloud seeding adds to the volume of water to be pumped. The volume of water pumped is apparently proportional to the amount of rain falling, at least for the CMT mine and surface water at Rosebery.

Costs associated with natural rainfall

The impacts of rainfall in general and extreme rainfall events on mining operations for CMT and Rosebery were listed above. The estimated costs are as follows:

1) Costs of pumping and treatment. CMT treats and pumps approximately 2,800 megalitres of water from the mine per annum, which is mainly from rainfall. The cost of treatment and pumping is approximately $2.3m per year
2) Costs if water influx exceeds capacity: flooding of lower levels of the mine delays the progress of development of access to future production areas. The impacts vary, though include:
    A) compensation payable to contractors due to lost development work. Compensation per event is approximately $500,000. Contractors continue to be paid and therefore do not experience damage/costs. Flooding of lower levels of the mine has in the past restricted development about once a year. There is no actual lost copper production due to these events, as the mine produces copper from the ore stockpile.
    B) Lost development opportunity will delay future ore production schedules, financial impact is unknown.
    C) Flooding can cause deterioration of development, cost of rehabilitation is approximately $120,000 per event.
    D) Flooding can damage non-mobile equipment (pumps and fans) and costs approximately $50,000 per event.

In addition CMT occasionally has a materials handling problem with its ore due to high rainfall when it becomes ‘sticky’. This may occur once or twice a year and can persist for about 4 to 8 weeks. Sticky dirt may reduce the throughput and copper production by approximately 20% equivalent to 5% to 6% of annual production of 30,000 tonnes of copper at $9,000 / tonne) = $13.5m to $16.2 per annum in production. The value of lost production overstates the economic cost, better represented by the value added. The direct value added lost is likely to be of the order of $7 million but considering economic flow on effects, the total cost to the Tasmanian community (not all to the West Coast) would be about $13 million based on value added multipliers for mining in Tasmania.

The total cost associated with rainfall for the mine are therefore about $2.3 + $.67 + $13 = $16 million at this mine.

Total pumping costs for surface water handling at Rosebery are $200,000 per year.

In addition to the CMT's active mine, the State government is responsible for discharges from 6 old Mt Lyell mines which are closed. These old mines discharge polluted water as rain water percolates through the soil. While a number of remediation projects have been examined, none has been implemented to date apart from diversion of some surface water from acid affected areas. The Environment unit of the Department of Tourism Arts and the Environment is currently investigating new approaches for remediation. While it is expected that additional rainfall will have an effect on future operating costs, this cannot be quantified, as the expected operating costs are not known. In the meantime, additional rainfall is likely to increase the extent of acid mine drainage occurring and any environmental impacts this has.

Additional costs from cloud seeding

Costs associated with pumping and mine flooding are considered by the mine operators to be proportional to the amount of rainfall. These amount to about $3.2 million per year in areas that may be affected by cloud seeding, A maximum possible 8% increase in rainfall due to cloud seeding in the seeding season implies an additional rainfall of 5% over the year with costs of $160,000 per year. However, if additional cloud seeding effects are close to 0% in Queenstown and less than 4% in Rosebery, additional costs could be as low as $10,000.

The relationship between increased rainfall and the costs of handling sticky ore is not as clearly proportional to rainfall, occurring once or twice per year after heavy rainfall and then persisting for a period. These figures could be greater if the incidence of the sticky dirt problem at CMT is affected by cloud seeding.

2.3.8 Health and welfare

Rainfall effects

It has been noted in the social and economic profile of the West Coast that a number of health indicators are poorer than for Tasmania as a whole. These include higher standardised death rates (SDR) for circulatory diseases and respiratory ailments as well as poisonings and injuries. In the past, the SDR for cancer has shown higher rate than for Tasmania but more recent figures show it has moved closer to the state average.

The review of the status of health in the region does note the potentially depressive effects of cloud cover and rainfall, coupled with the isolation from other parts of the state. However, the only statistics cited that have an apparent link to this are the higher rates of suicide and attempted suicide.

It is not clear that there is a causal relationship between rainfall and most of the adverse health conditions identified as being more prevalent on the West Coast. The health status report cited a number of other specific causes including higher rates of smoking, overweight, higher alcohol intake, lack of physical activity and lower use of and poorer access to health care services. Some of these may be indirectly attributable to high rainfall.

Additional cloud seeding effects

Cloud seeding does not create additional rainy days nor contribute significantly to additional cloud cover on the West Coast. The additional rainfall may contribute to some extent in the reduction in outdoor activities as describe in **2.3.5 Deferred or otherwise affected activities**. In that section it was estimated that at most about 3 outdoor community events may be affected by cloud seeding over and above those affected by normal rainfall. In some cases this would affect attendance at an event rather than lead to the cancellation of the event. This is unlikely to make a significant difference to the overall level of health outcomes given the other factors identified.

Costs associated with natural rainfall

Rainfall most likely does contribute to some of the increased health risks and poorer health outcomes on the West Coast. However, the contribution of cloud seeding to this is expected to be negligible and so total costs of rainfall effects have not been calculated.

Additional costs from cloud seeding

These are expected to be negligible.

2.3.9 Loss of residents

Rainfall effects

Many respondents to the community consultation noted the gloom effects of persistent rainfall. In some cases it was cited as a source of discouragement to customers in their business, either as visitors or in terms of attracting additional residents.

Areas with a reputation for extreme weather generally have trouble attracting or retaining residents: persistent wind on the Bass Strait Islands, the extreme dryness of much of central Australia and the extreme heat of both some inland areas and the far north. While only one factor, the perception of high rainfall (and the experience by residents) may be a contributor to the small and falling population of the region.

We noted that the average length of residence of respondents to the community survey was quite long, with a relatively smaller proportion of respondents being recent arrivals. It is as if some people can tolerate the relatively rainy climate and remain, whereas many who move to the area do not. Alternatively it may simply reflect the long term decline in population with those still committed to the area for the long term dominating among those remaining

Additional cloud seeding effects

Many respondents perceive that cloud seeding adds to the number of rainy days, the intensity of rainfall and the overall gloom of the area that results. The climate professionals consulted as part of this project expressed extreme scepticism that people could detect the effects of cloud seeding without the aid of rain gauges or other measuring devices. Rainfall is simply too variable to be able to observe such differences.

In practice, cloud seeding does not add to the number of rainy days but heavier or more persistent rain may increase the feelings of “gloom”.

However, it is worth considering the effects of the perception among some members of the community that cloud seeding does make the climate ‘worse’. If they become convinced that cloud seeding makes no practical difference, would it lead to further despair? “Even if they stop it won’t get any better.” Or would it lead to acceptance: “That’s just how it is so if we choose to live here, we had better get used to it.” No doubt the reaction would be different for different individuals.

Arguably the biggest impact would be on the extent to which focussing on high rainfall – whether cloud seeding induced or natural – may have a deterring effect on potential residents. This however, is not the result of cloud seeding, but the community’s reaction to their perception of cloud seeding and of course, of the high natural level of rainfall.

Our estimate of the actual impact of cloud seeding on the number of residents is that there is none. Any effects are the result of perceptions, something that arises from other causes.

2.3.10 Additional laundry, cleaning, flood damage

Rainfall effects

Having a wet and muddy environment will result in more splashes and wet clothes, increasing the need for laundry and cleaning vehicles and some other equipment. The extent to which this occurs will depend on the particular features of the environment, activities undertaken etc and the standard of cleanliness expected. In some instances, in spite of dampness or splashes, ‘normal’ cleaning cycles (eg weekly laundry or car wash) will still be followed. In other cases, the frequency of washing may actually be **reduced** due to the perceived futility of washing vehicles during persistent wet weather.

The effect of rainfall will most often be associated with the frequency of rainfall, with relatively minor effects from severity except where some degree of local or more widespread flooding occurs. The effects of flooding can vary dramatically, both in terms of the amount of property affected and the severity of the effects. Costs associated with flooding of buildings can be substantial when they occur.

One effect of frequent rainfall will be the reduced effectiveness of clotheslines. This is likely to increase the use of clothes dryers with associated power costs.

Additional cloud seeding effects

Cloud seeding does not affect the frequency of rainfall and so is unlikely to affect the main 'driver' of additional laundry and cleaning costs.

While cloud seeding affects the intensity of rain, it is not associated with the **most** extreme rainfall events which are usually summertime thunderstorms. Where it is associated with the relatively more extreme events, this is relatively infrequent. Further, not all extreme events result in flooding and damage. Even though cloud seeding may be associated with some extreme rainfall events, there is limited evidence that cloud seeding has ever been the cause of a specific flood event.

The flooding event on 13 August 2007 in Strahan has been cited by some as being caused by cloud seeding. However, the closest day that was seeded was on 4 August, over a week earlier. The flooding in that event was caused by very high levels in Macquarie Harbour and heavy flows in the Manuka River, with a catchment well outside seeded areas.

It is operational policy not to seed in locations where flood warnings are current, further reducing the likelihood of cloud seeding to cause flooding.

Costs associated with natural rainfall

Given that cloud seeding is unlikely to contribute to a significant difference in normal cleaning costs, no estimate is made of the effects of natural rainfall.

Additional costs from cloud seeding

No additional costs are expected to arise from cloud seeding.

2.3.11 Additional heating, lighting

Rainfall effects

Persistent rain is accompanied by persistent cloud cover. This reduces the amount of sunlight received with the result that dwellings and other buildings do not receive as much solar heating as they might otherwise. Dull overcast conditions also mean that artificial lighting is required for longer periods.

Some people perceive rainfall to have a cooling effect. In practice, the formation of rain droplets actually releases heat, and temperatures during rainfall are unlikely, on average to be lower than they would be on a cloudy but non-rainy day. However, there may be some additional psychological desire for heating on a rainy day, and heat may be required to dry out damp clothing.

Additional cloud seeding effects

Cloud seeding does not create cloud cover and therefore does not contribute to additional heating or lighting requirements compared to naturally cloudy conditions. It may intensify cloud cover for short periods, and add to perceptions of coldness and dark if rain is more persistent or heavier. However, the frequency of actual cloud seeding effects is low, only up to 20 days per year max and much less (about 7) in catchments near or including populated areas.

We estimate that there are negligible net additional effects from cloud seeding on heating and lighting requirements.

2.4 Benefits of rainfall

When faced with frequent often heavy rain, it is worth reflecting that if frees the West Coast from many of the problems faced by people in areas where there is not enough rainfall. Clearly the West Coast community is mindful of this in their not infrequent comments that they have enough rain already, it would be better that more fell elsewhere in the state However, the dynamics of the weather are such that it is not simply possible to transfer the excess from the West Coast to other places by moving the clouds or cloud seeding operations around.

The West Coast does benefit from an adequate and regular water supply for town water and for industry. The amount of irrigation required is minimal compared to most of the rest of the state and much of the country. Arguably this has some benefits in reduced cost of supply and quality of life.

Substantial regular rainfall is also the basis of the hydro electricity capacity of the region. While less than in the past, this still makes an economic contribution to the region and a substantial one to Tasmania.

We have not attempted to quantify the benefits of regular rainfall.

2.5 Benefits of cloud seeding

At various times, Hydro Tasmania and its predecessor the Hydro Electric Commission have estimated the value of cloud seeding operations in order to assess the value of continuing cloud seeding experiments and cloud seeding operations. We note that this is not a benefit specifically to the West Coast, but to Tasmania as a whole, of which West Coast residents share only a portion.

Estimates of the value of cloud seeding depend on the amount of additional water captured in hydro storages and its value when used to generate electricity. Estimates of additional rainfall in turn depend on assumptions about seeding operations, with more recent operations becoming more selective about their choice of suitable seeding days leading to lower seeding frequency.

For a given estimated amount of additional runoff captured by storages, the manner in which this affects the operation of the system will vary according to system demand, and the availability of alternative power sources and the storage level at which these are invoked. Early estimates were developed when the Tasmanian electricity market was separate from the rest of Australia and there was only an oil fired generator of limited capacity as back up to the system. However, in the earliest estimates, the hydro system had some spare capacity relative to demand in average years. In these conditions, additional runoff is as likely to result in increased energy in storage as to serve immediate demand. But if the storages then become full and there are one or two years of above average rainfall, some of this stored water (energy) will spill and the benefit will be reduced. For this reason, estimates of the benefits of additional rainfall from cloud seeding depend on simulations of typical patterns of rainfall, system load and operations to determine probabilistic estimates of outcomes. We have simplified this by reporting estimated average outcomes as the best indication of value.

The changes in situation affect the calculated results. For later estimates, average demand approached system capacity more closely and the manner of operation changed, invoking possible supply from oil fired power more often to ensure that storage levels did not fall to the point of having a high risk of power shortages. More recently the availability of Basslink and lower cost gas fired capacity at Bell Bay has again changed the dynamics of operation, affecting the potential energy yield from cloud seeding.

Estimates of potential runoff increases with cloud seeding have varied. The 2000 estimate of value used estimates ranging from about a 4% gain in the seeding season for King catchment up to about 9% for the eastern central highlands for the seeding season. The estimates used by Hydro Tasmania in its most recent assessment have been based on the lower assumed increases in inflow shown in Table 3. Note that the averages of assumed increase in inflows at 2.9%-5.4% are considerably lower than those used earlier and those assumed when estimating maximum impacts in earlier sections of this report, which assumed up to 8%. The difference is most pronounced for the King and Upper Pieman catchments, those closest to the West Coast communities.

Table 3. Estimated percentage increase in inflow, seeded months

Month	Great Lake, Lake Echo (Target East)	Lake St Clair, Lake King Will. (Target West)	Mersey Forth	Upper Pieman	King
April	0.0	4.4	4.2	2.9	2.7
May	0.0	4.1	3.0	2.5	2.2
June	0.0	6.1	5.0	3.7	3.1
July	0.0	5.1	3.7	3.3	2.6
August	0.0	5.2	4.2	3.3	3.2
September	0.0	5.3	5.2	3.6	2.9
October	0.0	6.1	5.6	4.1	2.9
November	0.0	6.9	7.3	4.5	3.6
Simple avg for seeded months	**0.0**	**5.4**	**4.8**	**3.5**	**2.9**

Source: Cloud Seeding Estimation of Benefits, Hydro Tasmania, internal report 2006

With changes in both the way the system is operated and some changes in estimates of the runoff yield from cloud seeding, estimates of the energy value of cloud seeding have varied. The most recent estimate is that cloud seeding contributes the equivalent of a power station putting out 12 MW continuously. (An earlier estimate (2000) was that it was equivalent to 20 MW).

Prior to the introduction of Basslink and the conversion of Bell Bay power station from oil to gas, the potential **dollar value** of cloud seeding was very much higher. At that time, if the hydro storages held insufficient water to ensure continuity of power supply, the cost of alternatives to hydro were much higher (e.g. burning oil at Bell Bay power station). Further, there was limited capacity from other sources to guarantee continuity of supply, so maintaining adequate storage capacity was particularly critical.

In these conditions, the estimated benefit of cloud seeding was of the order of $20 M per annum. With the introduction of Basslink and local gas fired backup, the dollar value of replacement electricity has fallen, and the latest assessment undertaken in 2006 it was estimated to be valued at $3.9 million per year. However since then electricity prices have risen further, and the value of renewable energy credits has also increased substantially, making the value closer to $5m. It is expected that this may rise again further in the future. Most of the reduction in valued from 2000 to 2006 is based on the reduced energy supply cost should the energy from cloud seeding not be available, but some also reflects a lower estimated power output based on more conservative run off estimates and a different operating regime.

The estimated benefit also has to take into account the cost of the cloud seeding contract and administration. This varies somewhat according to the number of flights, between about $1.2-$1.3 million per year. Thus, for the most recent estimates, the net benefit of cloud seeding is at least $3.7 million per year at current pricing.

As Hydro Tasmania is a State government owed business, the benefits accrue to all Tasmanians, not just to West Coast residents. Based on a population of just under half a million, the net benefit is about $7.50 per person per year. In terms of the total West Coast population of about 5150, this amounts to about $38,000 per year.

Other effects of cloud seeding are the substitution of hydro electricity for coal or gas fired electricity, reducing greenhouse gases. The availability of additional peak energy supplies reduces the spot price of electricity, reducing costs for consumers and industry. These benefits have not been costed.

2.6 Comparison of costs and benefits

The estimate for the benefits of cloud seeding on power generation (Section 2.5) is based on much more conservative estimates of the likely increase in rainfall than the cost estimates in Section 2.3. The assumption behind power generation was for a maximum additional runoff of up to 7.3% (in Mersey Forth, November), but average increases of around 5%. Notably, in the catchments closest to the West Coast community, Upper Pieman and King, increases are much smaller, a maximum of 4.5% but with an average closer to just over 3%. This is far lower than that assumed in the sections on costs (ie a maximum of about 8% per month in the seeding season and in areas outside of the target catchments).

A fair comparison of costs and benefits should use the same assumptions for both. If the 8% effect in and near the King and Upper Pieman catchments was used to calculate benefits, net benefits would be much higher, more than double the amount estimated by Hydro Tasmania at about $8-$10 M. Hydro Tasmania has not supported assessment of the benefits of cloud seeding at this level as realistic based on their expected rainfall gains and current electricity prices.

More realistically, the high estimates for costs based on rainfall increases of 8% in the previous sections are almost certainly too high. That is, these are very generous, worst case assessments, with actual impacts likely to be substantially less.

There is one possible scenario in which the higher costs calculated in Section 2.3 could occur with lower benefits to Hydro Tasmania consistent with Section 2.5: if targeting of cloud seeding is so bad that more rainfall falls outside the target area than within it. None of the analysis of cloud seeding experiments offers any evidence for this whatsoever. In fact, evidence that cloud seeding has a significant effect outside of target areas is limited, suggesting that effects outside the target areas are weaker than inside them as intended. Therefore any effect outside target areas will be less than within them and probably less than the estimated yield figures used by Hydro Tasmania.

Table 4 summarises a comparison of maximum and minimum costs and benefits for cloud seeding. For Tasmania as a whole, cloud seeding offers a substantial cost benefit of at least $3.7 million. For West Coast residents, the benefits exceed the cost for the minimum impact estimate, but costs exceed the direct benefits to the West Coast community for the maximum impact estimate. Costs in this case are heavily dominated by the costs to the west coast mines (two thirds) rather than the broader community.

Table 4. Comparison of costs and benefits

	Cloud seeding impact	Estimated max additional cost, normal rainfall	Cloud seeding additional cost	
Cost item			**Max**	**Min**
Construction	Minimal	$600,000	$15,000	$0
Maintenance	Minimal	$750,000	$10,000	$0
Building structures	None	ne		
Infrastructure	Some	$650,000	$21,000	$5,000
Deferred or cancelled activities	Minimal	$120,000	$6,000	$1,000
Lost tourism business	Minimal	$1,800,000	$12,500	$0
Mine operating costs	Significant	$16,000,000	$120,000	$10,000
Health and welfare	Negligible	ne		
Loss of residents to the region	None	ne		
Cleaning, Floods	Unlikely	ne		
Heating and lighting costs	None	ne		
All costs (rounded up)			**$185,000**	**$20,000**
Benefits of cloud seeding				
Additional power generated net of seeding costs	Direct			
- Statewide benefit			$8.0 million	$3.7 million
- Benefit to West Coast residents			$80,000	$38,000
Regular reliable water supply	Negligible	ne		
All calculated benefits				
- Statewide benefit			**$8.0 million**	**$3.7 million**
- Benefit to West Coast residents			**$80,000**	**$38,000**
Net benefit (rounded)				
- Statewide benefit			**$7 million**	**$3.7 million**
- Benefit to West Coast residents			**-$105,000**	**$18,000**

ne: not estimated as no additional effects from cloud seeding expected.