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COSTING DUST

How much does wind erosion cost the people of South Australia?

FINAL REPORT

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Executive Summary

The answer to the question "What does wind erosion cost the people of South Australia", is either $3 million or $23 million.

Asthma

The choice between these two estimates depends on one's assessment of emerging research findings (Rutherford *et al.*1999) on the interdependence of wind erosion, dust and asthma. Correlations are being found. If correlation turns into causation then our estimates have significant policy implications.

If new research findings from Queensland can be transferred to South Australia, then there is a case for significant public investment in activities that seek to reduce the off-site costs of wind erosion.

Estimates

We estimate direct market values. No attempt has been made to estimate non-market values. Moreover, as we have not been able to send out a formal survey, we have provided a range of estimates. Assuming the health-related assumptions of our work are correct, we estimate the following annual off-site costs of wind erosion for South Australia.

- Most likely cost of annual off-site impacts $23 million
- High estimate $56 million
- Low estimate $11 million

If health costs are excluded then the extent of off-site impacts is relatively small. Our non-health estimates are

- Most likely cost of annual off-site impacts $3 million
- High estimate $6 million
- Low estimate $1 million

Conclusion

In short, the case for public investment in wind erosion projects depends on research results that have just been published. If the findings and our assumptions are correct, there is a strong case for public funding.

We recommend that

- the State should support more research into the relationship between wind erosion and dust from rural sources on asthma and general respiratory health; and
- effort be put into assessing the range of marginal benefits and costs associated with reductions in wind erosion on the assumption that wind erosion, dust and asthma and general respiratory health causal pathways are confirmed.

Finally, we consider that our estimates are of national and possibly international significance. Consequently, we recommend that the findings from this report be released for public discussion. We stress, however, that these estimates are based on new research findings that have not been widely corroborated.

Steering Committee

- Glen Gale, PIRSA
- Doug Young, PIRSA
- Giles Forward, PIRSA
- Richard Payne, PIRSA
- Brian Hughes, PIRSA
- Chris Rudd, PIRSA
- Peter Butler, PIRSA

Project requirements

To deliver a detailed, ideally, regionalised estimate of the off-site costs of wind erosion in South Australia and, in particular, to:

- quantify, as far as possible, the magnitude of these costs by region – A matrix showing the IMPACT of costs by Region; and
- identify as far as possible the source of these costs – A matrix showing the SOURCE of wind erosion costs.

Preface

This report focuses on the external costs of off-site Wind Erosion reflected in the market place. Prepared for PIRSA, its prime purpose is to assist in assessing the merits of projects and determining cost-sharing arrangements.

As far as we are aware, this is the first objective study of the off-site costs of wind erosion that has ever been conducted in Australia.

Throughout the project, we have been ably assisted by an enthusiastic Steering Committee who, as well as guiding us through the study, also assisted us to develop a number of the estimates used. We would like to acknowledge their contribution with gratitude.

During our meetings, the Steering Committee asked us to focus on market rather than non-market dimensions of the off-site impacts of wind erosion. This report does this.

The task we were asked to undertake is a difficult one. Information on wind erosion in South Australia is limited and the State is large. Moreover, the budget for this project, given what was asked for, was relatively small. The result is an estimate based on the best information that could be assembled within the available time. All estimates are presented as a minimum, an estimated median and a maximum value. We regard these numbers as a first cut attempt to scope the likely extent of annual costs.

In addition to thanking our Steering Committee, we would also like to thank Shannon Rutherford who made her draft papers available to us; Monica Nitschke, for excellent advice on the asthma literature and putting us in touch with the information on asthma costs which came to dominate our findings; Fred Tiong, for the excellent job he did in assisting us to identify road accident costs caused by wind erosion; Grant McTainsh, who provided many key elements and background data which made this study possible, and Paul Huszar and Steven Piper for sharing their data with us. We would also like to thank all the people who responded readily to our phone calls and requests for information.

HOW MUCH DOES WIND EROSION COST THE PEOPLE OF SOUTH AUSTRALIA?

Introduction

The question this report seeks to answer is

> *"In terms of direct financial off-site impacts, how much does wind erosion cost the people of South Australia?"*

Wind erosion and dust storms are both a naturally occurring and human-induced phenomenon. Moreover, unlike many other land degradation processes it is extremely episodic in nature. In the recent past, severe dust storms were relatively common. However, as indicated in Figure 1, since the early 1970's the frequency of dust storms across Eastern Australia has diminished considerably. The reasons for the change in the frequency of dust storms are not fully understood but are thought to be associated with a decline in long fallowing and a general change in land management practices (McTainsh 1993).[1]

South Australian studies

South Australia has some literature on the on-farm impacts of wind erosion and following several severe dust storm events, reports have been written on the impact that these events have had on the State.

Information on the extent and nature of wind erosion in South Australia is well summarised in three reports. As well as summarising events on severe wind erosion days, they also review much of the related literature. The reports are

- Dust storms in South Australia on 24-25th May, 1994 (Butler *et al*., 1995);
- An assessment of wind erosion on Eyre Peninsula during 1988/89 (Hughes *et al*., 1990); and
- Wind erosion on Eyre Peninsula, 1975-1979 (Wetherby *et al*., 1983).

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[1] It is assumed that these data apply as equally to South Australia as they do to other States.

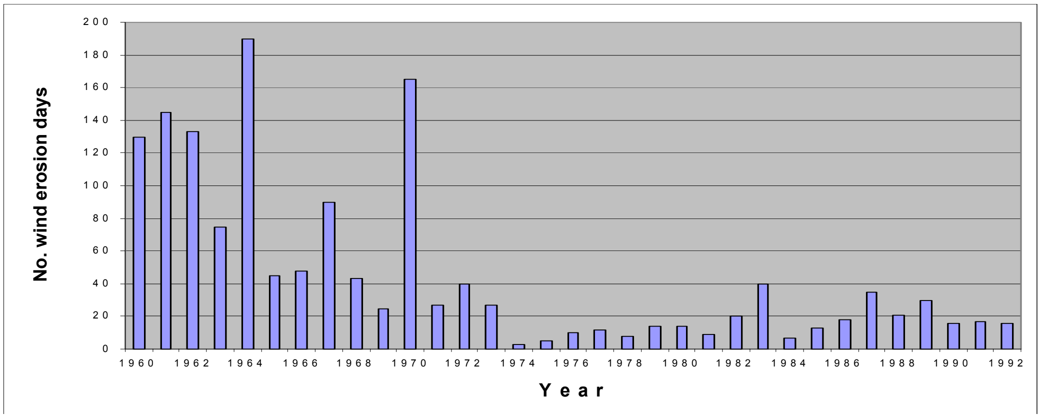

Figure 1 Total number of dust storm days from 41 Eastern Australian weather stations (adapted from State of Environment Advisory Council, 1996)

Economic estimates

The focus for this report is on the off-site costs of wind erosion. While, as far as we can tell, there has been no attempt to cost wind erosion off-site impacts in Australia, there has, however, been one major study in the USA that is reported in a series of several papers by Huszar and Piper. All these studies have been drawn from data collected for Piper's Masters Thesis. This thesis analyses the off-site costs from wind erosion in the State of New Mexico in the United States of America. Huszar and Piper (1986) divided the State into major land resource areas and surveyed household and businesses on the impact of wind erosion on their activities. The main conclusions from Huszar and Piper's research are that

- the off-site cost of wind erosion in New Mexico was estimated to be 50 times greater than the on-site cost of wind erosion;
- 90 to 95% of these costs are associated with landscape damage, the increased cost of house cleaning;
- major costs incurred were in areas of high population density and high frequency of dust storms;

- costs are not always a direct function of dust storm severity – a moderate dust storm can require as much clean up as a severe dust storm;[2] and
- the greatest returns come from reductions in widespread and severe but infrequent events.

Methodology

The aim set out for this study was to deliver a detailed and ideally regionalised estimate of the off-site cost of wind erosion and in particular, to

- quantify, as far as possible, the magnitude of these costs by region; and
- to identify, as far as possible, the source of these costs.

We interpreted this to require us to prepare what we call an "impact matrix" and a "source matrix". The impact matrix tabulates all costs and where they occur by region. The source matrix is a redistribution of the costs back to the region from where the dust originated from. The approach we took was to:

1. Identify regions for analysis.
2. Develop a means to categorise wind erosion events.
3. For each region, estimate the frequency of wind erosion events by category so that we could estimate the likely probability that each will occur in the next year.
4. Identify the range of cost centres that wind erosion has an impact on.
5. For each cost centre, develop a low, median and high estimate of the per unit cost of wind erosion.
6. For the next year, estimate the likely impact of wind erosion for each region and cost centre in South Australia.
7. Using Steering Committee judgements, attempt to redistribute these costs back to the origins of the dust by regions.

Regions for analysis

The regions chosen for analysis are those used by the Australian Bureau of Statistics with some minor modifications.

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2 They report that "The same amount of time and effort is necessary to vacuum a carpet with one millimeter of soil as with two millimeters of soil."

The four statistical sub-divisions that form Adelaide are amalgamated into one region, and the Onkaparinga and Fleurieu sub-divisions are also amalgamated. As indicated in the tables below, all other sub-division boundaries are maintained.

Categorisation of wind erosion events

To simplify the task and on the advice of our Steering Committee, we decided to use a categorical approach to the development of estimates for each region. Following a careful review of the available data, we identified four types of wind erosion event:

1. Severe wind erosion days when visibility is reduced to less than 200 metres, over very large areas of the state.
2. Moderate wind erosion days when visibility is reduced locally to less than 1,000 metres, but not over most of the state.
3. Days when there is some "dust in the air" as defined by the EPA as periods when the total suspended particulate matter TPS)>150$\mu g/m^3/hr$.
4. Zero wind erosion days TPS<150$\mu g/m^3/hr$.

Visibility data is available from the Bureau of Meteorology and limited information on dust in the air is available from South Australia's EPA.

As a general rule, the Bureau of Meteorology records visibility at recording stations when they are staffed. Such data is available for over 40 locations around the State but contains considerable missing data items (see Appendix 2). The station must be operational and a recorder must be present. There are 9 permanently staffed stations. To overcome missing data problems, we mapped the data and sorted the information by time to develop an estimate of the extent of declines in visibility on each day for the last 20 years. Assuming that next year has an equal chance of being the same as any of the previous 20 years, we then developed wind erosion probability estimates for each category.

Severe events

In the last 20 years, there have been two severe dust storms in South Australia. The first occurred on 16th February 1983 and the second on 24th May 1994. There was a further large dust storm across most of the Eyre Peninsula on 7th November 1988.

We assume from this that, on average, one can expect 0.1 severe wind erosion days per year.

Moderate events

Moderate events are those where visibility is reduced but only over a local area. As already noted, data on this type of event is patchy. Given the resources available, we could only estimate frequencies for each region on the basis of subjective interpretations of the data available. As shown in Table 1, the frequency of these events varies significantly from one region to another. Decline in visibility is much more common in the North than in the South of the State.

Dust in the air

As information available to us suggests that there maybe an association between wind erosion and asthma and general respiratory health, we also developed estimates of the frequency of days when there is some detectable dust in the air. Such data is available from the South Australian EPA for Port Pirie and Adelaide. Port Pirie data was not used, however, as all the recording stations are in close proximity to large industrial sites. For the ten sites in Adelaide, information is available for days when the total mass of suspended particles in the air (TPS less than 100 μm) is greater than 150 $\mu g/m^3$/hour. But samples are only taken once every six days from each of the ten sites. We assume that this is representative of the full range of days. For Adelaide, this resulted in an estimate of 8.5 "dust in the air" days per year.

The next challenge was to convert the number of "dust in the air" days per year in Adelaide to estimates for all the other regions of the State. As there is no data, we assume a linear relationship between "dust in the air" days and days when the Bureau of Meteorology records a decline in visibility conditions. A proportional change in one is matched by a proportional change in the other. The result of all the above estimates is summarised in Table 1.

Table 1 Estimated annual frequency of wind erosion events

ABS Region	Wind erosion category		
	Severe*	Moderate*	Dust in the air**
Adelaide	0.10	0.22	8.18
Barossa	0.10	0.22	8.18
Kangaroo Island	0.05	0.10	3.83
Onkaparinga and Fleurieu	0.10	0.22	8.18
Yorke	0.10	0.30	8.95
Lower North	0.10	0.19	7.41
Riverland	0.10	0.37	12.01
Murray Mallee	0.10	0.37	12.01
Upper South East	0.05	0.10	3.83
Lower South East	0.05	0.10	3.83
Lincoln	0.10	0.57	17.13
West Coast	0.10	0.57	17.13
Whyalla	0.10	0.57	17.13
Pirie	0.10	0.65	19.17
Flinders Ranges	0.10	0.19	7.41
Far North	0.10	2.27	60.58

* Estimated from 20 years of Bureau of Meteorology Data on visibility

** Estimated from 17 years of EPA data when TPS > 150µg/m^3/hr

The range of cost centres

In order to make the task as tractable as possible, there was a need to identify the prime cost centres where wind erosion is likely to have off-site impacts. To do this, we reviewed the available literature and consulted a large number of people. We also consulted managers of large factories and emergency service providers. In each case, we were informed that the marginal costs were trivial. Many factories reported that they had to clean their premises regularly and in those areas where protection from dust was necessary, they had to take precautions, regardless of the risk of dust from agricultural sources. The final result was a relatively short list of six main cost centres, namely impacts on:

- individual households;
- power supply;
- road safety;
- road maintenance;
- the cost of air travel; and
- human health.

Impacts on individual households

Research by Huszar and Piper (1986) suggests that many of the impacts on people are most efficiently estimated at the household level. Consequently, all our estimates are prepared on a per household rather than a per person basis.

As resources were limited, we decided to attempt to transfer estimates from the New Mexico study (Huszar and Piper 1986) to South Australia rather than conduct our own surveys. In the economic literature, this technique is known as 'benefit transfer'. The validity of this technique depends upon a number of criteria. In particular, when transferring estimates from one location to another, it is necessary to:

- have a high degree of confidence in the original study;
- be dealing with human populations of similar size and social characteristics;
- be dealing with similar types of damage; and
- be dealing with damage of a similar magnitude.

Given the time available for the study we were prepared to assume that results from New Mexico can be transferred to South Australia. The climate is not dis-similar, both areas used developed country agricultural practices and the standard of living is similar. Similar types of damage from wind erosion can be expected. The main difference between New Mexico and South Australia is the large number of houses in New Mexico that are made from timber. Timber houses are painted and, arguably, wind erosion may increase painting costs. Huszar and Piper report, however, that painting costs account for a very small proportion of total costs so we made no attempt to remove this estimate from the value transferred.

Huszar and Piper's initial analysis found that off-site wind erosion costs are partly a function of population density and partly proximity to dust source. In areas of high population density, there are a greater number of buildings and related structures, which act as wind breaks, but there are more households effected. Consequently, they classified New Mexico into two regions. *High impact areas* which tend to be close to the source of wind erosion and generally have low population densities; and *low impact areas* that tend to be further away from the source and/or have higher population densities. As summarised in Table 2, we classified South Australia regions using criteria similar to those developed by Huszar and Piper (1986) and then transferred their cost estimates to South Australia. [3]

Impacts on power supply

One surprising cost centre that we identified was the need for ETSA to clean power transformers after severe dust and moisture had collected on the transformers. When transformers are not cleaned there can be power leakage and circuits can trip out. Areas where this is a serious problem include Port Augusta, Port Pirie and Torrens Island. Average annual costs were reported to be $250,000 per year across the State. Last year (1998), the total cost was $120,000. In future, costs are expected to rise as penalties are being introduced as part of the COAG reform process. Given all the above, we assume the following statewide costs for power supply

- Median $250,000 per annum;
- Maximum $350,000 per annum; and
- Minimum $120,000 per annum.

The spreadsheet model we built assumes that these costs are shared proportionally across all households.

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[3] Huszar and Piper's 1984 estimate was converted to 1997 values using the US equivalent of the Australian CPI. Then converted into Australian dollars using a 4 year average exchange rate and updated from 1997 using the Australian CPI.

Table 2 Estimated range of wind erosion costs per household per region (1999 Dollars)*

	Low Impact Area**	High Impact Area***
Severe Wind Erosion Day		
- Median estimate	$23	$61
- High estimate	$37	$80
- Low estimate	$8	$46
Moderate Wind Erosion Day		
- Median estimate	$4	$23
- High estimate	$8	$37
- Low estimate	$0	$8
"Dust in the Air" Day		
- Median estimate	$0	$0
- High estimate	$0	$0
- Low estimate	$0	$0

* Transferred from Huszar and Piper (1984). Estimates are updated to 1997 prices using the USA CPI. Then converted using a 4 year average exchange rate and updated from 1997, using the Australian CPI.

** ABS Sub-divisions and Divisions: Adelaide, Barossa, Kangaroo Island, Onkaparinga and Fleurieu, the Upper South East, and Lower South East.

*** ABS Sub-divisions and Divisions: Yorke, Lower North, Riverland, Murray Mallee, Lincoln, West Coast, Whyalla, Pirie, Flinders Ranges, and Far North.

Impacts on road safety[4]

Another interesting finding was the extent of damage to vehicles whenever there is a severe dust storm. Unfortunately, many people do not understand the extent of risks associated

[4] We were unable to identify any impacts on railway maintenance costs.

with driving during a dust storm. To assist us, Fred Tiong from Transport SA examined the road accident data for days when severe dust storms have occurred in the State (see Appendix 1). He did this by predicting the number of accidents that would be expected during a normal day and then examining the number of accidents during 4 dust storms[5]. He estimated that these storms resulted in 12 additional crashes that are valued by the Transport SA at $115,000. Estimates are distributed across the State in the following manner

- Median cost $115,000 per severe dust storm event;
- Maximum cost $172,000 per severe dust storm event;
- Minimum cost $57,500 per severe dust storm event.

Pragmatically, we assume that the cost per household, per event, is the same across the entire State. Lacking data, we assume the minimum cost is half the median cost and that the maximum is above the median by a similar margin.

Impacts on road maintenance

Information on road maintenance costs caused by wind erosion proved difficult to identify. The approach we took was to contact Council Engineers to ask them for information on road maintenance costs induced by wind erosion. All said this information was difficult to supply as events occurred more than a year ago. The most common response was that the only impacts were those associated with sand drift next to highly eroding paddocks. When this occurs, councils are supposed to recover the cost of removing the drift from the land owner who caused the problem. Hence, in a strict sense none of these costs should be included in our assessment as they are costs that should be met by the landowner. Nevertheless, Hughes *et al*. (1990) in a Department of Agriculture Report written immediately after a major dust storm in 1988, states that this dust storm required the District Council of Franklin Harbour to spend an extra $250,000 on road maintenance. More recently, Dames and Moore in an unpublished report to PIRSA, have found similar evidence of some expenditure that is not recovered from land owners. Based on our general knowledge of the State, we assume that road maintenance costs per household are affected by wind erosion in the regions Riverland, Murray Mallee, Lincoln and West Coast.

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5 16 February 1983, 7 November 1988 and 24 to 25 May 1994

Building upon the data from Hughes *et al.* (1990), we assume that road maintenance costs per severe event per household in the above districts are

- Median cost $28.31;
- Maximum cost $50.00;
- Minimum cost $10.00; and
- Cost per household in Whyalla and Port Pirie are assumed to be half the above amounts and zero in all other regions.

Impacts on the cost of air travel

Another cost is the impact of severe dust storms on the cost of air travel. Inquiries among the general aviation industry revealed little indication that dust storms increase private flying costs. We did identify the fact that one 747 flight was diverted to Melbourne after three failed attempts to land in Adelaide during a dust storm on 24 May 1994. Building on cost information supplied to us, Table 3 summarises the range of costs that could be included under this item.

Table 3 Estimated annual cost of airline diversions
(Severe wind erosion events only.)

	On-ground incidentals	Extra flying time	Total Cost per diversion
Median	$20,154	$31,500	$51,654
High	$20,154	$63,000	$83,154
Low	$20,154	$15,000	$35,154

* There have been two severe wind erosion events in South Australia in the last 20 years. The 747s have only been landing in Adelaide since 1982 and on more regular basis since the 1990s. Even though there has been only one diversion we have kept the frequency at 0.1 per year.

Impacts on human health

The last and most important but controversial cost centre identified is that associated with estimates of the effects of wind erosion on human health. The question is whether or not dust from agricultural sources cause asthma and general respiratory problems. If there is a linkage and if dust from agriculture should be assigned a pro rata share of asthma costs, then the total off-site cost of wind erosion for South Australia is very large. Costs are associated with

- school absenteeism;
- work absenteeism;
- impairment;
- disability; and
- death (NEPC 1997).

In the course of investigating this question, we identified two estimates of the annual cost of asthma in Australia. One estimate, prepared the National Asthma Campaign (NAC 1999) puts the total annual cost in the range of $585 million to $720 million. The other estimate, prepared by the National Environment Protection Council (NEPC 1997), estimates the annual cost at $846 million excluding mortality and if mortality is included $ 4.6 billion.

Exploring the significant policy implications of this issue, Shannon Rutherford and her colleagues at Griffith University have been attempting to correlate data on the presence of dust in the air from rural sources with asthma symptoms. Their research (Rutherford *et al,1999*) is finding correlations between the presence of agricultural dust in the air and subsequent problems with asthma. Air samplers are used to collect TPS and PM10 samples onto filter papers. Rural dust is identified using a Munsell colour chart to separate "brown" rural dust from "grey" urban and industrial dust. So far, her team has tracked 14 dust events using diaries kept by between 33 and 76 asthmatics over a three-year period. The data shows significant increases in respiratory problems during days immediately after a period when there was significant amount of rural "dust in the air". Such events are defined as periods when the density of dust is greater than 150 $\mu g/m^3$/hour.

While it would be inappropriate for us to summarise the state of knowledge about dust and asthma here, Abramson and Beer (1998) report that there is a close association between dust particles less than 10µm (PM10) and asthma.[6] Much of the fine dust associated with wind erosion consists of clay particles is less than 2µm in size (Gates pers.com, 1999). Robinson (1999) reports that there is some indication that dust particles less than 2.5µm could be one of the prime causes of asthma. Moreover, as some clay particles are charged, there is a potential for pesticides and other environmental contaminants to cling to these particles (Juhasz pers. com., 1999).

In all cases, our approach to cost estimation is conservative. Table 4 summarises the best estimate that we can make for South Australia. It is based on a methodology developed by the NEPC (1997). Although we have not reviewed all the NEPC data, we consider some of their estimates to be high. Following Transport SA's practice, we adopted a lower value for each life lost as a result of asthma. Transport SA uses a figure of $700,000 per life. NEPC prefers a figure of $7 million per life.[7] We also assume that the number of people suffering from asthma in South Australian is in proportion to the State's population. South Australia has 8% of the total population of Australia. We assume that this means that South Australia contains 8% of the people suffering from asthma in Australia. On this basis, we estimate the total annual cost of asthma in the State is $97 million (see Table 4).

6 Abramson and Beer (1998) report that a 14% increase in annual mortality in six cities in the United States for each 10µg/m³ in annual PM 2.5 pollution. 10.

7 The NEPC study values a lost life at $7 million. This is 10 times the value put on lives lost on SA roads.

Table 4 Estimate of the cost of asthma in Australia*

Health Affect	Estimated annual number of people effected in Australia	NEPC cost with each life lost valued at $7,000,000 ($ millions)	Revised estimated cost with each life valued at $700,000 ($ millions)	South Australia's share of revised estimate (8%) ($ millions)
Mortality	531	3,717	372	30
Marginally reduced activity days	5,341,071	299	299	24
Reduced activity days	4,444,672	547	547	44
Total		4,563	1,218	97

* Adapted from NEPC (1997).

The last step in estimating health costs is to assess the proportion of the State's total asthma to wind erosion from rural sources. As far as we are aware, the only work done on this issue is that by Shannon Rutherford, (NEPC 1997) and Grant McTainsh. Following discussions with Grant McTainsh, and drawing on data available from Brisbane we assume that as much as 50% of asthma causing dust may come from rural sources. The median estimate of 20% comes from NEPC (1997) estimates for Perth. Similarly, the low estimate comes from the NEPC (1997) estimates for Newcastle. In summary, we assume the following proportions of the total cost of asthma in South Australia should be allocated to rural sources

- median 20%;
- high 50%; and
- low 10%.

We stress, however, that this study has only just been published, contains inconsistent relationships and has not been corroborated by similar research in South Australia.[8]

[8] In the United States, Hefflin, et al (1991) found a small correlation between respiratory health and dust from sources but no significant correlation with asthma.

The Impact Matrix

Having developed all the above estimates, the next task was to summarise the above data (Table 5) and construct an impact matrix showing the distribution of costs by region (Table 6). Consistent with Huszar and Piper's research, we find that costs are largely in proportion to population density.

From Table 5, it can also be seen that the estimate is dominated by costs attributable to impacts on human health (asthma). If further research confirms that agricultural dust has a significant impact on asthma and general respiratory health in South Australia, then the off-site cost of soil erosion is a very significant item. If it does not, then the off-site costs of wind erosion in South Australia are almost a magnitude lower.

Table 5 Estimated annual off-site costs of wind erosion in South Australia by cost centre (1999 Dollars)

Cost Centre		Nature of Estimate		
	Cost Share	Median	High	Low
Health	85%	19,953,602	49,884,006	9,976,801
Household	13%	3,039,926	5,080,862	1,227,596
ETSA	1%	250,000	350,000	120,000
Air Travel	0.01%	2,583	4,158	1,758
Road Accidents	0.1%	23,000	34,500	11,500
Road Maintenance	0.4%	88,209	176,296	33,837
Total		$23,357,320	$55,529,822	$11,371,492

Table 6 Estimated annual off-site costs of wind erosion in South Australia by region - The "Impact matrix" (1999 Dollars)

	Nature of Estimate		
Region	Median	High	Low
Adelaide	16,162,975	39,281,423	7,790,149
Barossa	625,363	1,519,842	301,409
Kangaroo Island	58,208	143,005	28,582
Onkaparinga & Fleurieu	878,685	2,135,497	423,504
Yorke	462,583	1,025,433	239,299
Lower North	351,363	789,770	184,193
Riverland	679,666	1,487,500	346,153
Murray Mallee	646,036	1,413,897	329,025
Upper South East	264,199	649,083	129,728
Lower South East	617,372	1,516,755	303,144
Lincoln	583,422	1,244,938	288,044
West Coast	135,470	289,074	66,884
Whyalla	529,763	1,146,128	267,011
Pirie	599,345	1,286,872	299,923
Flinders Ranges	386,547	868,855	202,638
Far North	376,322	731,749	171,807
Total	$23,357,320	$55,529,822	$11,371,492

The Source Matrix

The last task we undertook was to attempt to redistribute the estimated costs to their source. Ideally, this should be undertaken using wind erosion models and wind direction data. As time and the budget were limited, we briefed our Steering Committee on the nature of Bureau of Meteorology wind data during severe and moderate wind erosion events. We then asked them to redistribute costs back to the regions where they thought the dust associated with each wind erosion category originated from. The result is a set of tables showing costs by source of the problem. We call this a "source matrix". For each region, costs were reallocated by spreading 20 counters across a map of South Australia in proportion to their perception of the most likely source of dust. Each counter represented 5% of the total dust for that particular region. The results of this reallocation are summarised in Table 7.

Using this data, we then redistributed the cost estimates from impact matrix to the source matrix (Table 8). Four regions - Barossa, Adelaide, Lower North and Yorke – account for over half the total estimated value of off-site wind erosion costs in the State. Conceptually, and assuming equal technologies, these areas have a larger proportion of costs that are of a public rather than private nature. In such areas, it is possible to argue that a larger proportion of project costs should be paid for from public sources.

One of the issues that the Steering Committee found hardest to deal with was the degree to which "dust in the air", as we describe it, moved long distances. As a result, we asked them to provide an alternative assessment of the distribution of estimated wind erosion costs for Adelaide. Table 9 contains this revised estimate. More costs are reallocated to regions further from Adelaide. The main shift is the repositioning of regions where a large proportion of wind erosion costs could, arguably, be paid for from public sources. In particular, the Barossa drops from first place to the third place in the ranking of regions where total off-site costs are highest and the Lower North moves to number one position.

Finally, it should be noted that all the costs are annual costs. Any investment that makes a perpetual 5% reduction in off-site wind erosion costs across the entire State would have a gross capital value of between $8 and $49 million with a best estimate of $23 million.[9] These findings are, however, conditional upon the health dimensions of this problem being confirmed for South Australia.

If there is no connection between asthma and wind erosion, then the gross capital value of a 5% reduction across the entire State falls to somewhere between $0.9 million and $4.0 million with a best estimate of $2.4 million. More-over, conceptually,

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9 This is a slight over-estimate. It assumes immediate adoption and a discount rate of 7%.

the nature of the opportunities to argue for a large proportion of project costs to be paid for from public sources change. With health included, 85% of the total costs come from "dust in the air" events that are relatively frequent and, we perceive, more easily reduced as there are more opportunities to do this. Without health benefits, public opportunities for net benefit are now quite limited as in the last 20 years the frequency of severe and even moderate dust storms has dropped significantly (see Figure 1).

Table 7 Overview of proportions used to redistribute estimated wind erosion costs to their source. (Mean of the different proportions selected by the Steering Committee on the basis of their knowledge of South Australian conditions)

Impacted Region ⇒ Source ⇓	Adelaide	Barossa	Kangaroo Island	Onkaparinga & Fleurieu	Yorke	Lower North	Riverland	Murray Mallee	Upper South East	Lower South East	Lincoln	West Coast	Whyalla	Pirie	Flinders Ranges	Far North
Adelaide	20	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Barossa	25	40	0	25	0	0	0	0	0	0	0	0	0	0	0	0
Kangaroo Island	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0
Onkaparinga & Fleurieu	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Yorke	15	20	40	15	45	10	0	0	0	0	0	0	0	0	0	0
Lower North	20	20	5	25	0	40	10	5	0	0	0	0	0	0	0	0
Riverland	0	0	0	0	0	0	75	55	25	25	0	0	0	0	0	0
Murray Mallee	0	0	0	0	0	0	0	30	45	40	0	0	0	0	0	0
Upper South East	0	0	0	0	0	0	0	0	30	30	0	0	0	0	0	0
Lower South East	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Lincoln	5	5	20	5	20	0	0	0	0	0	75	0	15	0	0	0
West Coast	0	0	0	0	0	0	0	0	0	0	15	80	5	0	0	0
Whyalla	0	0	5	0	10	10	0	10	0	0	0	0	40	0	0	0
Pirie	10	10	5	5	15	20	15	0	0	0	0	0	0	50	10	0
Flinders Ranges	5	5	5	5	10	20	0	0	0	0	0	0	5	40	50	20
Far North	0	0	0	0	0	0	0	0	0	0	10	20	35	10	40	60
Western Australia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Victoria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New South Wales	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Territory	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Queensland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8 Redistribution of wind erosion cost estimates on the basis of Steering Committee understanding of the nature of wind erosion events in Australia - The "Source Matrix"

Region	Total costs		
	Median	High	Low
Barossa	4,499,801	10,929,349	2,167,343
Adelaide	4,103,680	10,003,314	1,962,407
Lower North	3,853,855	9,314,581	1,866,388
Yorke	3,023,631	7,304,051	1,468,407
Lincoln	1,580,071	3,660,623	780,844
Pirie	1,517,697	3,500,614	742,029
Whyalla	1,132,761	2,698,896	568,116
Riverland	714,466	1,526,913	366,272
Far North	590,629	1,237,709	294,550
Flinders Ranges	549,981	1,143,255	276,924
Murray Mallee	507,908	1,171,987	250,274
Upper South East	401,141	989,150	197,284
West Coast	285,697	624,021	140,574
Onkaparinga & Fleurieu	240,521	583,984	116,985
Lower South East	191,011	473,588	94,286
Western Australia	61,889	133,487	29,303
New South Wales	54,584	135,717	27,279
Northern Territory	30,791	56,164	13,762
Kangaroo Island	17,205	42,419	8,465
Victoria	0	0	0
Queensland	0	0	0
Total	$23,357,320	$55,529,822	$11,371,492

Table 9 Modified redistribution of wind erosion cost estimates on the basis of Steering Committee understanding of the nature of wind erosion events in Australia - The "Source Matrix"

Region	Total costs		
	Median	High	Low
Lower North	4,499,801	10,929,349	2,167,343
Yorke	4,103,680	10,003,314	1,962,407
Barossa	3,853,855	9,314,581	1,866,388
Adelaide	3,023,631	7,304,051	1,468,407
Lincoln	1,580,071	3,660,623	780,844
Pirie	1,517,697	3,500,614	742,029
Flinders Ranges	1,132,761	2,698,896	568,116
Whyalla	714,466	1,526,913	366,272
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Far North	549,981	1,143,255	276,924
Murray Mallee	507,908	1,171,987	250,274
Upper South East	401,141	989,150	197,284
West Coast	285,697	624,021	140,574
Onkaparinga & Fleurieu	240,521	583,984	116,985
Lower South East	191,011	473,588	94,286
Western Australia	61,889	133,487	29,303
New South Wales	54,584	135,717	27,279
Northern Territory	30,791	56,164	13,762
Kangaroo Island	17,205	42,419	8,465
Victoria	0	0	0
Queensland	0	0	0
Total	$23,357,320	$55,529,822	$11,371,492

Concluding comments

This report began with the question "*In terms of direct financial impacts, how much does wind erosion cost the people of South Australia?*"

In Queensland, constrained by the available resources, the answer is conditional. Emerging research is revealing a significant correlation between asthma-related breathing problems and wind erosion from rural sources. If these findings transfer to South Australia the off-site impacts of wind erosion are of significant policy importance. If they are not then the case for public investment is limited.

On the basis of the information available to us, we believe that the case is strong. We recommend that

- the State support more research into the relationship among wind erosion, asthma and respiratory health; and
- effort be put into assessing the range of marginal benefits and costs associated with reductions in wind erosion on the assumption that wind erosion, dust and asthma causal pathways are confirmed.

Finally, we consider that our estimates are of national and, possibly, international significance. Consequently, we recommend that the findings from this report be released for public discussion. We stress, however, that these estimates are based on new research findings that have not been widely corroborated.

References

Abramson, M.J. and Beer, T. (1998) Something particular in the air we breathe? *Medical Journal of Australia* 169:453-454.

Butler, P.R.; Davies W.J. and Leys, J F. (1994) Dust Storms in South Australia on 24-25th May, 1994. Primary Industries, South Australia. Technical Report Number 243.

Dokery, D.W. and Pope, C.A. (1994) Acute respiratory effects of particulate air pollution. *Annual Review of Public Health* 15:107-132.

Hughes, B.W.; Wetherby, K.G.; Kew, G.A. and Lewis, D.L. (1988/89) An Assessment of Wind Erosion on Eyre Peninsula during 1988/89. Department of Agriculture South Australia. Technical Report No. 167, May 1990.

Huszar, P.C. and Piper, S.L. (1986) Estimating the off-site costs of wind erosion in New Mexico. *Journal of Soil and Water Conservation* 41(6):414-416.

Huszar, P.C. (1989) Targeting wind erosion reduction measures based upon off-site costs. *Journal of Soil and Water Conservation* 44(6):612-615

Huszar, P.C. (1989) Economics of reducing off-site costs of wind erosion. *Land Economics* 65(4):333-340

National Asthma Campaign (1999) Report on the Cost of Asthma in Australia National Asthma Campaign, South Melbourne.

National Environmental Protection Council (NEPC) (1997) Towards a national environmental protection measure for ambient air quality. Discussion papers. Adelaide: NEPC June and November, 1997 http://www.nepc.gov.au

McTainsh, G.H. and Leys, J.F. (1993) Chapter 7 – Wind erosion. In: **Land degradation processes in Australia.** McTainsh, G.H. and Boughton, W.C. (eds) Longman-Cheshire, Melbourne, pp188-233.

McTainsh, G.H.; Lynch, A.W.; and Hales, R. (1997a) Particle-Size analysis of aeolian dust, soils and sediments in very small quantities using a Coulter Multisizer. Earth Surface Processes and Landforms – Technical and Software Bulletin, 22, 1207-1216.

McTainsh, G.H.; Kiefert, L.; Nickling, W.G.; and Lynch, A.W. (1997b) Size characteristics of aeolian dusts in E. Australia, with Saharan comparisons, submitted for publication in *Sedimentology*.

Piper, S. and Lee, L.K. (1989) Estimating the Off-site Household Damages from Wind Erosion in the Western United States. Economic Research Service, Washington, DC. Resources and Technology Division, June 1989:34.

Piper, S. (1989) Measuring Particulate Pollution Damage from Wind Erosion in the; Western United States. *Journal of Soil and Water Conservation* 44(1):70-75.

Piper, S. (1990) Considering off-site wind erosion benefits in the decision to implement soil conservation practices: An example using the conservation reserve program. *Applied Agricultural Research* 5(3):153-158.

Piper, S. (1989) Estimating the off-site benefits from a reduction in wind erosion and the optimal level of wind erosion control: an application in New Mexico. *Journal of Soil and Water Conservation* 44(4):334-339.

Robinson, D.C. (1999) Something particular in the air we breathe? *Medical Journal of Australia* 170:342.

Rutherford, S.; Clark, E.; McTainsh, G.; Simpson, R. and Mitchell, C. (1999) Characteristics of rural dust events shown to impact on asthma severity in Brisbane, Australia, *International Journal of Biometeorology* 42:217-225.

Wetherby, K.G.; Davies, W.J. and Matheson, W.E. (1983) Wind Erosion on Eyre Peninsula, 1975-1979. Department of Agriculture, South Australia. Technical Report No 31. August, 1983.

Hefflin, B.J.; Jalaludin, B.; McClure, Ex.; Cobb, N.; Johnson, C.A.; Jecha, L.; and Etzel, R.A. (1994) Surveillance for dust storms and respiratory diseases in Washington State, 1991. Archives of Environmental Health 49(3): 170-174.

APPENDIX ONE EFFECTS OF DUST STORMS ON THE NUMBER OF ROAD CRASHES

Notes from Information supplied by: Fred Tiong, Transport SA.

Introduction

This exercise is carried out to find out if dust storms in SA resulted in increased number of road crashes. If indeed they do, the costs are also estimated.

Method

The 4 dust storm dates investigated were 16 February 1983, 7 November 1988 and 24 to 25 May 1994.

To see if the number of crashes on these dust storm days were above average, the expected number of crashes on non-dust storm days of the corresponding month and day of week were calculated and compared.

The crash data

Expected numbers were calculated as an average over a 3-year period encompassing the dust storm date. The 95% confidence interval (CI), based on the Poisson distribution, was then computed. If the number of crashes on a dust storm day was above the 95% CI, it is assumed to be the result of the dust storm. The calculations were carried out for property damage only crashes (PDO's), minor crashes and serious and fatal.

Results

Based on the calculations described above, it was found that these dust storms resulted in 6 PDO's and 6 minor crashes over and above the expected numbers. Details of the results are shown in the Attachment.

In 1998 dollars, the 12 additional crashes were estimated to cost the South Australian community $115,000 per severe storm.

APPENDIX TWO SUMMARY OF INFORMATION SUPPLIED BY BUREAU OF METEOROLOGY

The Bureau of Meteorology supplied us with the following and severe and slight or moderate dust storms were derived from this data in Comma Separated Variable (CSV)/text format:

- DUSTDAYS.CSV A listing of days when a dust storm has been observed;
- DUSTOBS.CSV A listing of observations when dust storms have been observed;
- SA_DICT.CSV A station dictionary of all SA weather and rainfall stations;

Notes describing the format and contents of these files are contained in the files

- DC_DATB.HTM Describes the observations in DUSTDAYS.CSV;
- HC_DAT2.HTM Describes the daily observations.

Significantly,

1. Some data extracted from the database contained incorrect data and have been deleted. Procedures are in hand to correct our database.
2. It is obvious that quality control procedures implemented by our National Climate Centre have not corrected up all errors and there may be some dust storms missing from the record or occasions wrongly identified as Dust Storms
3. Observations of dust storms, where the visibility is greater than 1 kilometre, should be treated with great caution.
4. Prior to 1987 only 0900hrs and 1500hrs observations for most stations were copied from field books onto the database. All observations were only copied from Bureau staffed stations.
5. After 1987 all available observations were accepted direct from the electronic messages.

The Bureau staffed stations are:

- Oodnadatta Airport (017043)
- Woomera (016001)
- Ceduna Airport (018012)
- Adelaide Airport (023034)
- Parafield Airport (023013)
- Edinburgh RAAF (023083)
- Adelaide (West Terrace) (023000)
- Adelaide (Kent Town) (023090)
- Mt Gambier Airport (026021)