TEMPERATURE INVERSIONS AT ANGLESEA, VICTORIA

By

T. T. Gibson and U. Radok

Meteorology Department, University of Melbourne
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ABSTRACT

As an exercise in simple microclimatic techniques, and as an aid in the correct dimensioning of power-station chimneys to be built at Anglesea, a one-year study of temperature and wind conditions was carried out in and above the valley of the Anglesea River. A nocturnal surface inversion was observed in the valley on about one-half of the nights of the year of observation (44% in summer and autumn, 63% in winter, 52% in spring), the occurrence of an inversion being dependent on the absence of wind in the valley. Consequently the inversions varied widely in duration and in intensity.

Thermograph and anemograph records made at the proposed power-station site in the valley, and thermograph records for points on the surrounding hills, comprised the basic data collected during the study. These were supplemented by regular pilot balloon wind soundings and occasional tethered-balloon temperature soundings, made during a three-month period in summer and a three-week period in early winter. Combined with the available radiosonde and pilot-balloon data from Laverton (50 miles to the north-east) these observations made it possible to construct an outline of the low-level nocturnal atmospheric structure over the Anglesea valley on inversion occasions, and to draw up a tentative frequency table of inversion heights showing the effects of the upper wind speed and direction, and of the stability of the layer immediately above the surface inversion.

I. INTRODUCTION

A major division in microclimatology is that between daytime and night-time conditions which differ basically in being general or representative and strongly local, respectively. In consequence of this a broad description of daytime conditions for a place or an area can often be achieved on the basis of topographical considerations and of meteorological observations for a not-too-distant existing station. At night on the other hand the role of local factors becomes so over-whelming that drastically different conditions can exist at negligible distances from one another. A direct study of the local microclimate then becomes essential and can represent a major task if detailed information is needed (e.g. Edinger (1963), Munn, Emslie and Wilson (1963)).
The study to be presented here was undertaken primarily as an experiment in microclimate assessment by simple techniques, but arose from the requirements of a rational decision on the height of a set of power station chimneys. The power station in question is being built by Alcoa of Australia Pty. Ltd. on top of browncoal deposits in a coastal valley near Anglesea, 65 miles southwest of Melbourne. The chemical composition of the Anglesea coal makes it more than normally desirable to ensure an effective diffusion of the effluents.

There is little argument regarding the meteorological measurements needed for a full description of diffusion conditions. When the problem was raised, a program of aircraft temperature soundings was suggested together with upper wind measurements using photogrammetry of rocket-laid, initially vertical, smoke trails (cf. Morgan and Radok (1965)). Such a program undoubtedly would have provided far more definite information than the restricted study which cost and manpower considerations made practicable.

Broadly speaking this study aimed at relating a limited amount of nocturnal wind and temperature observations at and above Anglesea to similar data for Essendon and Laverton, two aerodromes 50 miles away on the western outskirts of Melbourne. The correlations established between these places were to be used for inferring the essentials of the low-level atmospheric structure above Anglesea from several thermograph records and a recording anemometer, operating for a full year at the power station site (The Farm - see Fig. 1) and on the surrounding hills. The principal observation points are marked on the map, Fig. 1.

The local topography is characterised by several shallow valleys converging from the coastal plateau (generally 300 to 400 ft above sea level) into the valley of the Anglesea river where the power station is to be located. Upper wind and temperature measurements were made in this area by student observers under the direction of the authors during two periods: the first of these covered the entire summer of 1964/65 when D. Beaumont and R. Bannister acted as observers, while the second, with J. Straede and R. Tonkin, lasted from 25 May to 13 June and provided a sample of winter conditions. A particularly well developed inversion on the night of 25/26 June was also studied in order to gain an idea of extreme winter conditions.

In the following the special observations will first be discussed and then will be used for the interpretation of thermograph and wind records covering the full year from 1 September 1964 to 31 August 1965, in terms of atmospheric structures in and above the Anglesea valley.

2. UPPER AIR MEASUREMENTS AT ANGLESEA

A description of the overall meteorological conditions during the periods of intensive study at Anglesea is provided by regular upper wind soundings made with 20 gm balloons, inflated to give ascent velocity of 500 ft/min, and single theodolite at 30 second intervals. 223 such flights were made during the summer and 70 during the 20-day winter period, in addition to 13 double theodolite flights checking the rate of ascent. Normally two pilot balloons were launched soon after sunset in conjunction with a temperature sounding and another two before sunrise; for continuity, a fifth regular wind flight was made as close as possible to the time of the surface temperature maximum in the early afternoon. Occasionally, on nights of especially well developed inversions, wind and temperature soundings were carried out throughout the night.

The temperature soundings initially were made with 350 gm balloons tethered by means of a thin 4-strand nylon-covered copper cable with a breaking strength of more than 30 lb. This cable formed part of a resistance bridge with a thermistor as temperature sensitive arm.

The heights achieved with this method depended very much on the wind velocity, the balloon tending to drift horizontally once the wind velocity increased to more than 6 knots. At a later stage a ktyoon, available by courtesy of the PMG Research Laboratories, was substituted for the 350 gm balloon, and this proved rather more manageable in winds up to 10-12 knots. On the whole, however, the free air temperature information resulting from the study is restricted to the relatively calm surface layer. 36 soundings were made during the
Fig. 1  Anglesea and surrounding district.
Fig. 2  Anglesea and Essendon 1000 ft wind roses [a] for summer 1964-65 [b] for 25 May - 13 June 1965

Fig. 3  Comparison of [a] summer 1964-65 and [b] May - June 1965 Essendon 3000 ft wind roses with corresponding long term wind roses.
summer, to heights ranging from 40 to 700 ft. In the winter period considerable technical troubles arose from the wear of the balloon cable and only 8 temperature soundings were achieved; however, 5 of these covered a period of 48 hours and the final sounding, through the pronounced inversion of 26 June, reached a height of over 1000 ft.

The limitations of the temperature sounding technique imply that the upper air temperatures at best provided sample illustrations of typical inversion developments in summer and winter. Apart from this reservation it must be emphasized that the entire observational material obtained for Anglesea was no more than a relatively small sample. No long-term instrumental data exist for this locality from which the typical or atypical nature of the year of study could be assessed, but an idea of this may be obtained from comparisons with long-term records for neighbouring stations in the case of meteorological elements known to be representative for areas rather than a restricted locality only. The nocturnal temperature structure near the ground decidedly does not belong to this group, but the upper winds well above the ground at Anglesea would not be expected to differ greatly from those at Laverton and Essendon, the aerodromes 50 miles away on the western outskirts of Melbourne, where long-term wind records are available. As first step in our analysis we therefore compare the upper winds observed at Anglesea with those found simultaneously, and in the mean, over Essendon.

3. THE UPPER WINDS AT ANGLESEA AND ESSENDON

In the present context the flow and temperature conditions in the lowest 1,000 ft are of principal interest. The Anglesea measurements provided in all almost 300 wind values for the layer 750-1000 ft which can be compared with the routine 1000 ft winds. Such comparisons using only such Essendon wind observations as were matched by practically simultaneous Anglesea observations are given for summer and winter in Fig. 2.

The main difference in summer appears to be a slight preponderance in southeasterlies at Anglesea as compared with Essendon's greater share of northerlies. This difference is probably a sea breeze effect; it implies that using upper winds for Essendon or Laverton would in summer bias considerations in an unfavourable direction since winds from the northern sector pose the main diffusion problem for the Anglesea township. In winter, Fig. 2b again shows a smaller proportion of direct northerlies for Anglesea than for Essendon, but in this case the sample is too small for great confidence to be placed in the significance of the difference.

Of particular interest for the diffusion problem is the extent and incidence of the light-wind surface layer. The tethersonde runs provided a direct, if somewhat arbitrary, definition of such a layer since they effectively were terminated in each case when the wind reached or exceeded 6 knots. Frequency distributions of the heights at which this occurred showed little change with season in the incidence of calm surface layers, most of which were restricted to the lowest 250 ft.

To judge the conditions during this study against a long-term background, the Essendon wind observations used in Fig. 2 were compared with their climatological normals. Fig. 3 makes it clear that both the May/June and especially December 1964 through February 1965 differed substantially from the 20 year "normal" as regards upper wind direction frequencies. December and part of January were unseasonally windy, wet and cold, while the winter period failed to produce the calm anticyclonic weather typical of early June. The special measurements of 26 June were in fact undertaken to make up, at least in part, for that deficiency.

From a climatological point of view, therefore, the upper air data collected at Anglesea are quite inadequate. However, apart from providing correlations with the conditions above the Melbourne aerodromes they serve to illustrate typical inversion conditions and processes which will now be discussed.
4. THE ANGLESEA VALLEY INVERSION

A typical summer night inversion in the Anglesea valley is illustrated by the winds and temperatures for 14/15 January in Fig. 4. The broken line indicates the level at which the sideways drift of the tethered balloon put an end to further vertical sounding; as mentioned earlier, experience together with the pilot winds has shown that this indicates wind velocity in excess of 6 knots. The temperature throughout increased from the surface up to that level.

Above it a few structural features can be deduced from the observed winds. Towards the end of the night there is evidence of a weak low-level jet of the kind discussed, for example, by Blackadar (1957). Details of the formation of such a jet have been provided by observations made on an instrumented television tower at Cedar Hill, Texas, (Izumi 1964)) which show the greatest wind shear just below the inversion base. Applying this to Fig. 4 one would suspect from the rapid increase in wind velocity with height that the inversion base at the end of the night was around the 700 ft level.

For further information we turn to the nearest upper air sounding station at Laverton, 50 miles from Anglesea. Although situated in completely flat country this station is not far from the shore of Port Phillip Bay, providing a similarity to Anglesea as regards land-water contrasts. However, the regular radiosounding at Laverton takes place at 9 a.m. and in summer regularly shows the dry adiabatic lapse rate up to a height of several thousand feet. Although surface inversions undoubtedly prevail at Laverton on clear nights in weak winds, all traces of the nocturnal temperature structure are eliminated soon after sunrise by convection in summer.

On the occasion of Fig. 4 the temperature subsequently rose to 95°F at Laverton and 92°F in the Anglesea valley. According to the radiosounding (not reproduced) the tethersonde temperatures in Fig. 4 were generally below those existing in the lowest 3000 ft above Laverton the next morning. It thus appears that the valley inversion occurred below a deeper stable layer.

Somewhat more definite conclusions can be drawn along similar lines in winter when a good deal of the nocturnal temperature structure is preserved by the radiosounding. Fig. 5 summarises the conditions during the period 9 to 12 June 1965. The growth and decay of the light-wind surface layer has been constructed with the help of the pilot balloon winds, the surface wind record for the valley station, and a few observations of wind speed made along the slope of Scrubby Hill by means of a hand-held anemometer.

The temperature soundings themselves were not used in the construction of the calm layer boundary. Fig. 5 thus establishes the fact that the calm layer on this occasion included both a marked surface inversion and a layer of slight lapse above it. The increase in wind speed with height put an upper limit on the kytoon soundings and the temperature structure above these levels must again be inferred from other evidence.

On the evening of 10 June the light-wind layer started forming at about 6 p.m. Clouds impeded radiational cooling until about 8 p.m. but the sky then cleared and a very intense surface inversion had formed by midnight when the sky clouded over again. The break-up of the inversion was caused by several factors, starting with a break-through of the flow at higher levels down to the surface shortly after 4 a.m. and later by the advection of warmer air (cf. Fig. 6). However, relatively light winds persisted near the surface until almost 9 a.m.

The sequence of events during the following night differed markedly from that described above. This time the sky did not clear until almost 10 p.m. and even after that the radiational cooling was less intense than the night before, due probably to a 10 per cent increase in the moisture content of the air during the day. With the weaker inversion the upper flow was able to break through to the surface for a while around 11 p.m. and to destroy the calm surface layer altogether soon after 1 a.m.
Fig. 4 Anglesea wind and temperature observations Jan 14 - 15, 1965.
Fig. 5  Anglesea wind and temperature observations June 10 - 12, 1965.
Fig. 6  Temperature soundings for Anglesea and Laverton, June 10 - 12, 1965.
We now compare the temperature soundings obtained on these occasions at Anglesea with the conditions revealed on the following mornings by the radiosonde flights at Laverton, 50 miles away. These comparisons are made in Fig. 6, where in each case two Laverton soundings are given, to bring out changes which occurred in the interval. The points marked "A" and "L" above the word "max" below the temperature scale indicate the maximum temperatures observed at Anglesea and Laverton on the days in question and the dash-dot lines indicate the temperatures which may be presumed to have prevailed in the surface layer near the time of the maximum. The lowest sections of the Laverton soundings have been constructed to end at the minimum surface temperature, while the actual radiosonde temperatures near the surface at 9 a.m. are given by dotted lines.

It appears from Fig. 6 that the surface inversions at Anglesea were throughout somewhat shallower and more pronounced than at Laverton. This is fully in accord with what would be expected from the topography of the two places, and making allowance for such differences the temperature curves for Anglesea can be extrapolated to higher levels without much difficulty, and even in some detail when time sequences such as that given in Fig. 5 are analysed.

A particularly clear-cut example of such an analysis is illustrated in Fig. 7 by the measurements made during the night of 25/26 June which was marked by strong radiational cooling in a slack anticyclonic pressure field. Surface temperature changes during the night and the following morning are shown in the inset of Fig. 7 where the full, broken and dotted lines refer to thermographs on Scrubby Hill (370 ft), the valley floor (30 ft), and an intermediate ridge (130 ft), respectively. The two top curves suggest the existence of waves on the surface layer of very cold air in the valley.

The kytoon sounding (heavy line in main diagram) shows that on this occasion the cold air extended to 500 ft. At Laverton (thin curve) the stable layer was again considerably deeper. The thin dotted dry adiabat corresponding to the maximum temperature at Laverton (allowing for a slight over-heating of the surface layer) defines a triangular area which is a measure of the radiational energy used on the day in question for the heating of the surface layer. In absence of clouds other than an extensive sheet of thin cirrus (which covered both the Anglesea and Laverton areas) a similar amount of energy must be assumed to have gone towards modifying the surface layer at Anglesea. This defines a presumable shape for the Anglesea temperature profile above the 1000 ft level, as indicated by the heavy broken line.

A check on this deduction is provided by the shape of the thermograph curves. It will be noted that the heating rate in each of the three curves decreases abruptly as the $10^\circ$C ($50^\circ$F) isotherm is approached. A dry adiabat drawn through that surface temperature in the main diagram passes through the top of the cold surface layer. The reduced heating rate thus confirms the existence of a substantial layer of steeper lapse rate above the surface inversion. Still higher, another inversion is implied both by the Laverton sounding and by the change to lighter easterly winds at Anglesea. The upper winds at Anglesea suggest a well developed low-level jet around sunrise, which is in striking contrast to the otherwise calm conditions prevailing throughout this period and agrees well with the Cedar Hill pattern (Izumi (1964)).

The above shows how the essential features of the temperature structure above the Anglesea valley can be deduced from surface-based thermograph records, provided conditions are clear-cut (i.e. little cloud and no change in overall weather conditions during the night and the following morning). This implies that the surface temperatures recorded on Scrubby Hill in inversion conditions bear a close relation to the free air temperatures measured approximately 110 metres above the valley which is confirmed for all available tethersondings in Fig. 8. Additional evidence is provided by temperature measurements made during the night of 25/26 June at a number of points along a four-mile section extending southwest from the Geelong road above Anglesea to the fire lookout tower on Mt. Ingoldsby, 400 ft above the valley floor. The measured temperatures are shown as heavy numbers in Fig. 9 and have been used to sketch tentative isotherms for the valley. There is a very slight tendency for the isotherms to dip down into the valley but, on the whole, Fig. 9 supports the conclusion reached from Fig. 8 that on the average horizontal temperature gradients over the valley cannot be large.
Fig. 7 Temperature soundings for Anglesea and Laverton, June 26, 1965.
Fig. 8  Comparison of Scrubby Hill temperatures with simultaneous free air temperatures at the same level above The Farm.

Fig. 9  Isotherms [°C] over the Anglesea Valley - 0400-0600, June 26, 1965.
A procedure for the analysis of clear-cut thermograph traces is set out schematically in Fig. 10. For simplicity the height difference, $\Delta h$, between Scrubby Hill and the valley is set equal to 100 metres. $T_1$ and $T_2$ represent the minimum temperatures at these two points and the straight line joining them is taken to be a first approximation to the temperature profile in the valley. The top of the surface inversion is obtained by intersecting the extrapolated profile with the dry adiabat through the valley surface temperature, $T_3$, at which the rate of heating shows a sudden decrease, indicating that convection from the surface has reached a layer in which the upward heat flux is facilitated by a larger lapse rate. Since the dry adiabat has a fixed slope of $\Gamma = 1^\circ C/100\ m$, it follows from Fig. 10 that the temperature at the top of the inversion

$$T_i = T_1 + \frac{T_2 - T_1}{\Delta h} h = T_3 - h\Gamma$$

whence with $h$ and $\Delta h$ in units of 100 metres

$$h = \frac{T_3 - T_1}{T_2 - T_1 + 1}$$

and

$$T_i = T_3 - h$$

The ground inversion thus inferred can then be related to the Laverton sounding as in Figs. 6 and 7 to deduce the overall stability of the layer of interest here.

It should be noted that according to the Cedar Hill data the assumption of dry adiabatic conditions in the surface layer during the inversion breakup is quite realistic. The same data suggest that in the course of its destruction the inversion rapidly rises from the surface and temporarily becomes accentuated by subsidence in the higher layers.

5. SURFACE TEMPERATURES AT ANGLESEA

We have applied the above procedure for estimating the top height and temperature of the ground inversion to all suitable thermograms of the period 1 September 1964 to 31 August 1965, numbering 100 in all.

Surface temperatures were obtained at Anglesea by means of Lambrecht thermohygrographs exposed in white-painted metal screens. At the start of the investigation one of the thermographs was established at the "Farm", close to the future power station site, and another was placed on top of Scrubby Hill, a little over 100 metres above the valley floor. These two instruments operated during the entire period from 1 September 1964 to 31 August 1965. Two other thermographs were used for parts of the period at a number of different sites; their records have been used to check and supplement the Farm and Scrubby Hill data, and will not be discussed in detail.

Calibration of the thermographs was carried out in situ using two different methods. The four instruments were operated side by side on a bench in windy and cloudy conditions for a full day in May; furthermore, throughout the periods of measurements at Anglesea the thermographs were checked frequently by means of an Assmann psychrometer exposed inside the thermometer screens.

In the following we consider first minimum temperatures at Anglesea and Laverton for all actual inversion cases. From the most clear-cut of these cases statistics of the valley temperature structure will finally be determined.
(a) Minimum temperatures at Anglesea and Laverton

The following analysis concerns all cases of definite surface inversions at Anglesea. These numbered 193, or 53% of all nights in the year of study. In the long run, assuming a binomial distribution this figure would presumably range from 56% to 50% of all nights in a year with 95% probability. Table 1 gives the monthly average minimum temperatures obtained from the 1964/65 set, further sub-divided into "clear-cut" cases (for which estimates of the inversion height will later be made) and those with "disturbed" thermograms. Climatological minima have been added for comparison.

As would be expected, the difference between the overall average minimum temperature and the average for inversion nights only is throughout larger at the farm than on Scrubby Hill; the definite inversion cases include the lowest minimum temperatures for the valley but the highest minima for Scrubby Hill (where low temperatures are associated with windy, not calm, conditions).

A different statistical analysis of the valley minima in inversion conditions is given in Fig. 11 in the form of a cumulative frequency plot on a normal probability scale; the probability associated with any temperature is that of encountering lower minima on inversion nights, or very roughly twice the probability of encountering a lower minimum on any night of the year. For comparison similar information for Laverton is also given. Both the cumulative frequency distributions approximate to the normal shape and justify cautious extrapolation.

In the case of Laverton, 20 years of record are available in addition to the 1964/65 data used in Fig. 11 and the lowest minimum temperature on record is indicated by an arrow, near the point 25.4°F, 0.1%. In the Anglesea valley the minimum temperature on the average is 9°F lower than on the Laverton plain and at first sight this might suggest minimum temperatures of 15°F or 16°F as possible. However, the vicinity of the ocean with temperatures above 50°F throughout the year probably limits the valley temperatures to 20°F or higher, since an excess of cold air in the valley would tend to produce a land breeze circulation, preventing further cooling. The northerlies shown at the end of the night of 14/15 January in Fig. 4 may in fact represent such a land breeze.

To conclude the discussion of the temperature regimes at Anglesea, the reverse circulation or sea breeze must also be briefly considered, if only because if present in a shallow form it could conceivably create difficult diffusion conditions of the "fumigation" type (Wexler et al. (1955)) during the afternoon hours in summer. In the period 24 November 1964 to 21 April 1965 distinct sea breezes (marked by simultaneous changes in wind direction, temperature and moisture content of the air) occurred on 16 days, the times of onset ranging from 1045 to 1600, with a maximum concentration in the two hours following noon. The total number of sea breeze cases represents 11 per cent of all summerdays, probably an abnormally low figure, since the 1964/65 summer was marked by a prevalence of cold westerlies and southerlies. Thus again the available data serve mainly to give an idea of the form the sea breeze takes at Anglesea. In most of the 16 cases, the inflowing cooler air extended to at least 2,000 ft; this is in agreement with sea breeze observations made in South Australia by the Division of Meteorological Physics, C.S.I.R.O., (D. Reid, personal communication). Even in the rare shallow case, the sea breeze inversion had a height of around 1000 ft. In thus seems likely that diffusion difficulties created by sea breezes during summer afternoons would always be minor compared with those arising from nocturnal inversions.

(b) The thermal structures at Anglesea

Examination of all 193 inversion thermograms revealed in 100 cases clear indications of an abrupt change in the warming rate during the morning, suggesting that convection had reached the top of the pronounced valley inversion. The height and temperature of this upper boundary were estimated for all such cases in accordance with the argument presented at the end of Section 4. The resulting low-level temperature profiles for Anglesea were then plotted against the Laverton radiosoundings in the manner of Figs. 6 and 7 to determine the general character of the stratification above the Anglesea valley inversion, discrimination being limited to two broad classes, "stable" and "lapse". Finally the results were grouped in terms of the 1000 ft winds for each night at 2100, 0300 and 0900 local time at Laverton; in view of the
Fig. 10  Estimating inversion temperature $T_i$ and height ‘h’ [Schematic]
Fig. 11 Minimum surface temperature frequencies at Anglesea Farm [X] and Laverton Aerodrome [●] during inversion conditions in the period 1 September, 1964, to 31 August, 1965. Arrow shows the lowest minimum observed at Laverton in 20 years of record.
uncertainty of applying these winds to Anglesea only four broad direction sectors and two speed ranges were used.

Before giving the results of these calculations which summarise the present investigation as far as the practical diffusion problem in the Anglesea valley is concerned, it will be useful to assess their generality. In terms of temperature this can be done from Table 1 which shows that the clear-cut thermograms differed from the averages of all inversions in the same sense as the latter from the overall averages. Thus the inversion statistics that follow refer only to the most difficult quarter of all nights in the year, as far as inversion strength is concerned.

### Table 1

Minimum temperature averages for the Anglesea valley (Farm) and Scrubby Hill, September 1964 - August 1965. (°F).

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In terms of flow a similar assessment is made in Table 2 which compares the Laverton wind directions and speeds for the clear-cut and disturbed thermograms. Table 2 shows that while in terms of wind direction there was little difference between the occasions of clear-cut and disturbed thermograms, the former included more cases of strong than weak flow whereas the opposite applies to the latter. This is precisely what would be expected from the thermal difference of the two groups for inversions ending mostly below the 1000 ft level, and it further underlines the fact that the thermal structure estimates that follow represent the more accentuated inversion conditions rather than an unbiased sample.
Fig. 12  Cumulative frequency distributions of inversion temperatures \( T_i \) and heights \( h \)

Anglesea  September 1964 · August 1965
<table>
<thead>
<tr>
<th>Sector</th>
<th>No. of Obs.</th>
<th>Height range (ft)</th>
<th></th>
<th></th>
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<tr>
<td></td>
<td></td>
<td>0&lt;200 200&lt;400</td>
<td>400&lt;600 600&lt;800 800&lt;1000 &gt;1000</td>
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<td></td>
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<tr>
<td>070° - 150°</td>
<td>6</td>
<td>0 0 1 0</td>
<td>0 1</td>
<td>0 1</td>
<td>0 0</td>
<td>0 0</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>0 0 1 0</td>
<td>2 3</td>
<td>0 2</td>
<td>0 0</td>
<td></td>
<td></td>
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<tr>
<td>160° - 240°</td>
<td>23</td>
<td>0 0 1 1</td>
<td>1 5</td>
<td>6 1</td>
<td>0 0</td>
<td>0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 0 2 0</td>
<td>1 0</td>
<td>9 2</td>
<td>0 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250° - 330°</td>
<td>22</td>
<td>0 0 2 0</td>
<td>2 3</td>
<td>3 5</td>
<td>1 2</td>
<td>0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 0 2 0</td>
<td>2 1</td>
<td>8 4</td>
<td>0 1</td>
<td></td>
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<td>Calms and variable directions</td>
<td>17</td>
<td>0 0 0 0</td>
<td>0 0</td>
<td>6 1</td>
<td>7 3</td>
<td>1 1</td>
<td>0 0</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>0 0 0 0</td>
<td>1 5</td>
<td>1 1</td>
<td>0 1</td>
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<td></td>
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<tr>
<td>Total</td>
<td>100</td>
<td>1 0 2 1</td>
<td>6 12</td>
<td>12 11</td>
<td>3 5</td>
<td>0 1</td>
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<td>0 0 5 0</td>
<td>8 41</td>
<td>35 13</td>
<td>0 5</td>
<td></td>
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</tbody>
</table>

Table 3 needs no detailed discussion but it may be pointed out that for more than a quarter of the pronounced inversions (which accounted for a little under one third of all nights of the year) the estimated inversion top was higher than 400 ft above the valley floor. Taking the bottom righthand corner figures of the 340°-060° direction sector alone, one finds that 7 per cent of the pronounced inversions or 2 per cent of all nights of the year of study must have presented major diffusion problems for the higher parts of Anglesea township, SSW of the proposed power station.

6. CONCLUSIONS

The results here discussed retain a good deal of uncertainty and have to be interpreted cautiously in the light of long-term climatic data for the region. They show, however, that much can be established about microclimatic conditions by a judicious combination of local surface measurements with upper air data from a reasonably close aerological station.

ACKNOWLEDGEMENTS

We are indebted to the student observers who persevered with the protracted night observations required by the study and to the assistants of the Meteorology Department who took part in the extensive data analysis. Climatic background material was made available by the Bureau of Meteorology and especially the Bureau's Meteorological Office at Laverton. The observational program was supported by manpower and a grant from Alcoa of Australia Ltd.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year</th>
<th>Title and Details</th>
</tr>
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<tbody>
<tr>
<td>Edinger, J. G.</td>
<td>1963</td>
<td>&quot;The nocturnal cold layer in the Tunnyan valley&quot;. Facsiculo Informe 4, Departamento de Meteorologia, Universidad de Buenos Aires.</td>
</tr>
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