**Airflow and aeolian sediment transport patterns within a coastal trough blowout during lateral wind conditions**

**Abstract**

Blowouts are depressions that occur on coastal dunes, deserts and grasslands. The absence of vegetation in blowouts permits high speed winds to entrain and remove sediment. Whereas much research has examined patterns of wind flow and sediment transport on the stoss slopes and lee of sand dunes, no study has yet investigated the connections between secondary air-flow structures and sediment transport in a blowout where zones of streamline compression, expansion and steering are less clearly delineated. In this study we investigated the variability of sediment flux and its relation to near-surface wind speed and turbulence within a trough blowout during wind flow that was oblique to the axis of the blowout. Wind flow was measured using six, 3-D ultrasonic anemometers while sediment flux by eight sand traps, all operating at 25 Hz.

Results demonstrated that sediment flux rates were highly variable throughout the blowout deflation basin, even over short distances (< 0.5 m). Where flow was steadiest, flux was greatest. Consequently the highest rates of sediment transport were recorded on the erosional wall crest where flow was compressed and accelerated. The strength of correlation between sediment flux and wind parameter improved with an increase in averaging interval, from 10 seconds to 1 minute. At an interval of 10 seconds, however, wind speed correlated best with flux at seven of eight traps, whereas at an interval of 1 minute Turbulent Kinetic Energy (TKE) provided the best correlation with flux at six of the eight traps. Correlation between sediment flux and wind parameters was best in the centre of the blowout and poorest on the erosional wall crest.The evidence from this paper suggests, for the first time, that TKE may be a better predictor of sediment transport at minute scale averaging intervals, particularly over landforms where wind flow is highly turbulent.

**1. Introduction**

Blowouts are complex aeolian landforms that occur in coastal dunes (Carter *et al.,* 1990; Smyth *et al.,* 2013; Hesp and Hyde, 1996), deserts (Hesp, 2002) and grasslands (Hugenholtz and Wolfe, 2006). They are formed where vegetation is removed from the surface allowing high speed winds to entrain and remove surface sediments creating a depression. These depressions are morphologically variable (Smith, 1960; Ritchie, 1972; Smyth *et al.,* 2013) though are typically categorised as bowl or trough shaped (Hesp, 2002).

Sediment transport within blowouts has been measured using erosion pins (Jungerius and Verheggen, 1981; Jungerius and van der Meulen, 1989; Jungerius *et al.,* 1991; Pluis, 1992; Byrne, 1997; Bitton and Byrne, 2002, Hugenholtz and Wolfe, 2009), traps (Gares, 1992; Byrne, 1997; Bitton and Byrne, 2002) and topographic surveys (Gares and Nordstrom, 1988; Käyhkӧ, 2007). Only two studies, however, have measured sediment transport in relation to wind velocity and these were conducted at time periods of days (Hesp and Hyde, 1996) to months (Pluis, 1992).

To date, no studies have quantified sediment transport in relation to the secondary air-flow structures that occur in blowouts as a result of topographic adjustment of the incident wind-flow. Separated, accelerated and stagnated wind-flow, as well as corkscrew vortices (Jackson *et al.,* 2013) are common within complex blowout topography (Hesp and Pringle, 2001; Hesp and Walker, 2012; Pease and Gares, 2013; Smyth *et al.,* 2012; 2013). Recent work has shown that these zones of secondary wind flow remain surprisingly constant (spatially) even with fluctuations in wind speed (Smyth *et al.,* 2011; 2013), but vary significantly with incident wind direction (Hesp and Pringle, 2001; Smyth *et al.,* 2012, Pease and Gares, 2013).

Although there is a range of research exploring patterns of wind flow and sediment transport on the stoss slopes (Lancaster *et al.,* 1996; McKenna Neuman *et al.,* 1997; Davidon-Arnott *et al.,* 2012; Chapman *et al.,* 2013), in the lee of dunes (Walker, 1999; Lynch *et al.,* 2009; Lynch *et al.,* 2013) and beach dune systems in general ( Bauer *et al.,* 2012; Udo *et al.,* 2008), no study has yet investigated the connections between secondary air-flow structures *and* sediment transport in a blowout where zones of streamline compression, expansion and steering are less clearly delineated.

This paper presents the results of a field experiment designed to quantify the rate and variability of sediment flux within a trough blowout. The correlation of sediment transport with near surface wind speed and turbulence is also examined.

**2. Study site**

FIGURE 1

Field data were collected inside a trough blowout located landward of Tramore beach in County Donegal, Republic of Ireland (Figures 1 and 2). Tramore is a 4 km long, dissipative, north-easterly facing beach, located within Sheephaven Bay. It is bounded by a tidal inlet to the south and a rocky outcrop to the north (Figure 3). The Magheramagorgan dune field in which the blowout is located, is landward of a steep 10-12 m high foredune vegetated predominantly by marram grass (Ammophila arenaria) (Figure 3). Landward (100 m) of the foredune, is a 36-hole golf course. During the study period the golf course was not operational, though maintenance of the fairways was continued by regular grass cutting.

FIGURE 2

The blowout investigated was located immediately in lee of the foredune crest and orientated parallel to it. It measured 60 m along its axial length, 25 m at its widest point and 8.5 m at its deepest. Trough blowouts are typically characterised by a narrow opening known as a blowout ‘throat’ with steep, elongated, erosional walls flanking a relatively deep deflation basin (Carter *et al.,* 1990; Hesp, 1996; Hesp and Hyde, 1996; Hesp and Pringle, 2001; Hesp, 2002). A sediment accumulation known as a depositional lobe occurs at the downwind terminus (Hesp and Hyde, 1996; Hesp, 2002; Mir-Gual *et al.,* 2012). The blowout investigated in this study (Figures 2 and 3) comprises a shallow throat in the south-west which opens into a broad deflation basin. To the north along the blowout’s axis the deflation basin contracts and deepens toward a well-defined depositional lobe (Figure 3). The deflation basin’s south-west to north-east orientation corresponds with the prevailing wind conditions described by hourly meteorological data spanning 52 years from 1956-2008 at Malin Head (Figure 2), 40 km north-west of the study site (Figure 1). The surface of the throat, the deflation basin and erosional walls were comprised predominantly of bare sand. Surface sediment samples taken at six locations in the blowout indicated a mean grain size of 0.19 mm and a standard deviation of 0.01 mm, demonstrating a relatively uniform, very fine sand surface throughout the blowout.

FIGURE 3

**3. Methods**

To measure local wind flow dynamics at the site, five ultrasonic anemometers (3D Gill HS-50) were positioned throughout the blowout, 0.5 m above the sediment surface. The anemometers have a recording range of 0–45 m s-1 for wind speed and 0°-359° for wind direction. Both wind speed and direction can be sampled at a rate of 50 Hz; however, this was altered to 25 Hz to coincide with the sediment flux sampling rate. Four ultrasonic anemometers (UAs) were positioned inside the deflation basin and one UA was located on the crest of erosional wall (Figure 4 and Figure 5). To clearly define incident wind speed, a reference UA was also mounted 5.87 m above the dune surface 20 m south of station 1 (Figure 5). As flow inside blowouts is complex and typically not logarithmic in nature, no attempt was made to align the anemometer sensors to the local streamlines (Lee and Baas, 2012), instead, sensors were positioned horizontally. As a result, no quadrant analysis or Reynolds shear stresses were calculated in this study.

FIGURE 4

Sand trap construction was based on the load cell design of Jackson (1996) and consisted of 0.4 m external plastic casing and a 0.25 m diameter removable funnel. The trap was buried vertically so the funnel opening was coplanar with the sediment surface. Where the sediment surface was disturbed, the bed was raked flat prior to data recording. Trapped sediment was collected by a container and measured by a load cell with a resolution of 0.003 g operating at 25 Hz. All traps were bench tested in laboratory conditions before deployed in the field. An operating constraint of the load cell is that it must be positioned horizontally; therefore no traps could be located on the steep sided erosional walls of the deflation basin. Sediment traps were positioned in two arrangements. At stations 1, 2 and 3 sediment traps were located 0.225 m either side of the spar arm of the 0.5 m anemometer, level with the anemometer sensor to measure the spatial sediment transport difference on a small scale. At stations 4 and 5, the centre of the trap was aligned with the spar arm of the UA, level with the UA sensor (Figure 4).

FIGURE 5

**Analysis methods**

Total wind speed was calculated using the three constituents of the wind measured by the ultrasonic anemometer at a sampling rate of 25 Hz (equation 1) where u is the horizontal streamwise flow, v is the horizontal spanwise and w is the vertical component of the wind.

(1)

To calculate wind direction, the horizontal streamwise component of the wind was first aligned with geographical north. Direction was subsequently calculated as the opposite (-180) of horizontal flow vector (u, v) using the arctangent function (ATAN2) as in Jackson *et al.* (2011).

The calculation of standard deviation (SD) can be used as a proxy for fluctuations in wind speed and wind direction (Walker *et al.,* 2009). The coefficient of variation (CV) was calculated to normalise wind speed SD.

(2)

CV has also been used as a measure of variability for sediment flux rates (Lynch *et al.,* 2013). As sediment flux data is not continuous, however, nor is it normally distributed, this study measured flux variability by comparing per minute flux rates at each trap throughout the blowout. To measure the proportion of the study period that sediment transport was active, the Activity Parameter (AP) (Davidson-Arnott *et al.,* 2012) at each trap was calculated using data averaged at 10 second intervals. An AP value of 0.0 indicates that no transport has occurred while 1.0 demonstrates that sediment transport was recorded in each of the recorded sampling intervals.

Turbulence is defined by how much airflow deviates from the mean. Large amounts of turbulence may therefore greatly affect sediment transport. As turbulence is unaccounted for by mean wind speed, turbulent kinetic energy (TKE) was calculated at 10 second and 1 minute intervals using (3):

)

(3)

TKE has been used as an indicator of fluctuating wind flow and turbulence intensity in previous field studies (Weaver and Wiggs, 2011; Chapman *et al.,* 2012) and a computational fluid dynamic study over dunes (Parsons *et al.,* 2004) where it was hypothesised that it may maintain sediment transport in regions of flow retardation, for example at the toe of a dune. Though this paper is the first to perform the analysis, it had also been suggested by Chapman *et al.,* (2013) that TKE may provide improved association with sand transport than presently utilised parameters.

Correlations between sediment flux, wind speed and TKE were calculated using linear least squares regressions using averaging intervals of 10 seconds and 1 minute. Correlation between sediment flux and wind speed generally improves with increases in averaging interval as it tempers fluctuations in wind speed and wind direction which may affect the rate of sediment flux over short intervals (<10s) and negates any temporal lag between wind forcing and sediment transport (Baas *et al.,* 2006; Davidson-Arnott *et al.,* 2012).

**4. Results**

Results are presented from a 90-minute saltation event occurring between 10:00 am and 11:29 am on the 11th November 2011. Throughout the recording period, sand on the surface of the deflation basin was dry and no precipitation was observed.

FIGURE 6

**Wind flow**

Incident wind direction during the recording period prevailed from the south east at an average wind speed of 6.75 m s-1 as denoted by the reference UA located 20 m south of the blowout at a height of 5.87 m above the dune surface (Figure 6 and Table 1). Wind direction at the reference anemometer remained relatively steady, demonstrated by a wind direction SD of 13˚. Wind speed did, however, vary substantially from the mean (CV 24%) (Table 1).

INSERT TABLE 1

Wind flow within the blowout deflation basin underwent steering at two locations and substantial wind speed modification compared to the incident wind flow(Figure 6 and Table 1), as exemplified by the increase in wind speed CV and wind direction standard deviation by all the UAs within the blowout deflation basin compared to the reference UA (Table 1). UA 5, located on the crest of the erosional wall also recorded increased flow variability compared to the reference UA and a reduction in speed compared to the reference anemometer (Table 1).

TKE exhibited a range of 1.21 m2 s-2 between the six UAs. The greatest value was recorded at UA 5 located on the erosional wall crest, whilst the lowest was recorded at UA 1 situated in the blowout throat (Table 1). Whilst the results are much lower than those recorded by Smyth et al., (2012) who recorded TKE in a bowl-trough blowout during winds up to 17.72 m s-1, they display a similar distribution. In both cases the greatest values of TKE were recorded on the erosional wall crests, particularly at anemometers located on the erosional wall crest near the depositional lobe. Lowest values of TKE in each study were measured in the deflation basin.

**Sediment Transport**

The rate of sediment flux measured in the blowout differed substantially throughout the landform (Table 2 and figure 6). Sediment flux was greatest at the crest of the erosional wall. Whilst sediment flux rates within the deflation basin varied from between 77% and 13% of the rate recorded at the crest. The smallest values of flux within the deflation basin were measured in the easterly trap at location 1 and the greatest at the westerly trap in location 3 (Figure 3b). At locations 1, 2 and 3 where two traps were located 0.45 m apart to investigate local differences in sediment transport, the westerly most traps recorded a substantially higher flux rate, 32% to 82%, to those positions 0.45 m east of them (Table 2).

INSERT TABLE 2

The AP (Table 2) demonstrates that saltation was most active on the crest of the erosional wall at trap 5. Sediment flux within the deflation basin was most active at traps 3W and 3E located in the centre of the basin and lowest at the southernmost traps, 1W and 1E, located in the ‘throat’ of the blowout. Whilst the location of the highest AP is the same as the highest flux (trap 5), lowest recorded flux does not correspond to the lowest AP. Using all 9 traps a weak correlation (R2 = 0.39) between sediment flux (g m-1 min) and AP is calculated between flux and AP. Wind CV calculated from data averaged at a 10 second interval (Table 2) was also compared with sediment flux in figure 7. It exhibits a negative correlation (R2 = 0.89) demonstrating that as wind speed variability increases, sediment flux decreases.

FIGURE 7

A linear least squares regression was performed with flux and two wind flow parameters (wind speed and TKE) at averaging intervals of 10 seconds and 1 minute (Table 3). At the 10 second averaging interval wind speed provided a better correlation with flux than TKE at seven of the eight traps (Table 3), however, it is only a moderate to weak relationship, greatest at trap 3W in the deflation basin (R2 = 0.53) and poorest on the crest of the erosional wall at instrument location 5 (R2 = 0.23). At averaging intervals of 1 minute, correlation increases at each trap for both wind speed and TKE. Notably, however, at an averaging interval of 1 minute, TKE correlates better with flux than wind speed at six of the eight trap locations (Table 3). Using 1 minute averaged values of flux TKE, correlation is greatest (R2 = 0.69) in the centre of the deflation basin (Trap 2W), and weakest (R2 = 0.23) at the crest of the erosional wall (Trap 5). Where two traps were located with one UA, regressions derived from both TKE and wind speed at averaging intervals of 1 minute showed stronger correlation with flux at the western most traps (Table 3).

INSERT TABLE 3

**5. Discussion**

**Secondary wind flow**

Wind flow at a trough blowout where incident winds are perpendicular to the throat orientation has been described previously by Hesp and Pringle (2001) and more recently by Pease and Gares (2013). . This study differs considerably from both those investigations. Here we bring new insights into our understanding of flow behaviour in these environments using ultrasonic 3-D anemometry to examine wind flow speed, turbulence and direction over much higher sampling frequencies. The localised topography in our investigation also differs somewhat from the previous two studies in that the entrance of the trough blowout is not connected directly to the beach. Here, the blowout, including its entrance, remained confined behind the foredune parallel to the back beach.

Hesp and Pringle (2001) noted that incident winds that were oblique to the blowout (up to 100° from the long axis orientation) became ‘pulled’ into the blowout by a zone of low pressure inside the deflation basin and were then steered parallel to the blowout orientation. Pease and Gares (2013) found that winds up to an angle of 50° oblique to the axis of the blowout become steered along the deflation basin. Once the approach angle became greater than 50° wind flow within much of the deflation basin became more variable, resembling separated flow, however, axial parallel flow still occurred close to the entrance of the deflation basin. The wind flow characteristics described this study are similar to those of Pease and Gares (2013) as only wind flow at UA4 in the deflation basin (Figure 6) appears to have been steered parallel to the blowout long axis and toward the depositional lobe. The lack of axial parallel flow along the deflation basin at UAs 1 and 2 (Figures 4 and 6) may be due to the relatively shallow blowout throat in this case (Figure 3), compared to the blowout studied by Hesp and Pringle (2001). Incident flow is also greater than 100° oblique to the axis of the landform, far beyond the axial steering threshold found by Pease and Gares (2013). As a result, flow did not as readily become funnelled into and move along the axis of the deflation basin. Instead wind flow direction at UA’s 1 and 2 remained easterly (comparable to the incident wind direction) (Figure 6). Whilst no flow reversal was indicated by average conditions at UA 3 (Figures 4 and 6) in lee of the windward erosional wall of the blowout, as has been noted in several other blowout studies (Fraser *et al.,* 1998; Hesp and Walker, 2012; Smyth *et al.,* 2012, Pease and Gares, 2013), wind flow at UA 3 in the centre of the blowout was deflected parallel to the erosional wall, similar to wind direction in lee of a transverse ridge or foredune (Walker, 1999; Lynch *et al.,* 2013).Wind direction and wind speed variability (CV) at UAs 1, 2 and 3 located along the centre of the blowout were, however, characteristic of turbulent separated flow such as that in the lee of a dune crest or windward erosional wall (Wiggs *et al.,* 1996; Lynch *et al.,* 2009; Hansen *et al.,* 2009; Smyth *et al.,* 2012, Jackson *et al.*, 2013).

Wind flow at the crest of the erosional wall was faster and had much lower variability than that in the deflation basin. This is attributed to streamline compression and acceleration over the erosional slope (Fraser *et al.,* 1998; Hugenholtz and Wolfe, 2009). Wind direction over the erosional wall also became perpendicular to the crest, similar to wind passing over a fordune (Arens *et al.,* 1995, Hesp *et al.,* 2005, Pease and Gares, 2013 and Smyth *et al.,* 2013). The relatively low values of wind speed CV and wind direction SD imply that flow at this point was still undergoing streamline compression and had not become separated.

**Sediment flux variability**

Sediment flux within the blowout was highly variable ranging from 7.20 g m-1 min to 30.17 g m-1 , however, some spatial patterns were nonetheless identifiable. Where two traps were associated with one anemometer along the axis of the blowout (Stations 1, 2 and 3), sediment flux in the trap closest to the eastern erosional wall was substantially smaller. This may be attributed to the increased wind speed and steadiness of flow from east to west in the deflation basin as flow reattached subsequent to becoming separated in lee of the steep eastern erosional wall. The disparity between flux values for the traps located only 0.45 m apart highlights the heterogeneity of sediment flux within blowouts, even over times periods of up to 90 minutes.

Within the blowout deflation basin, sediment flux rates displayed a strong negative correlation with wind speed CV (Figure 7). Consequently, at UA 4 in the deflation basin and UA 5 on the crest of the erosional wall, where the steadiest and fastest wind flow occurred, flux rates were greatest. This is similar to the findings of Anderson and Walker (2006) who reported that the highest saltation rates occurred in steady topographically accelerated flow within a trough blowout, when investigating transport variations within a backshore-parabolic dune plain complex. The negative correlation between flux and wind speed CV demonstrates that sediment flux is dependent on the variability of wind flow at a very short timescale, validating the importance of recording wind flow data at high frequencies. Further investigation is required to understand how this relationship responds with changes in wind speed and in a range of blowout systems.

The flux rate at the crest of the blowout was between 1.3 and 7.6 times greater than rates recorded in the deflation basin while the percentage of the recording period during which sediment transport was recorded also varied substantially throughout the landform from a minimum of 42% of the time at trap 1W located in the throat (Table 2) to a maximum of 87% at the crest of the erosional wall. Whilst sediment flux was much larger at station 5 and sediment transport activity more consistent, this study was unable to confirm if the crest was undergoing erosion, or if station 5 was located at a confluence of flow where flow with entrained sediment from the deflation basin converged after becoming accelerated up the erosional wall. Within the deflation basin (traps 2, 3 and 4) the range in AP was much smaller (67% - 80%) conveying that sediment transport was relatively consistent. Interestingly, however, the correlation between flux and AP at the traps within the deflation basin is poor (R2=0.30). This discrepancy is particularly well illustrated between traps 3E and 4 where AP was comparable (range of 3%) but sediment flux was 283% greater trap 4, emphasising the variability of sediment transport flux within a small area subject to complex secondary flow patterns (Lynch et al., 2013).

**Temporal sediment flux and secondary wind flow correlation**

Temporal flux at 10 second and 1 minute averaging intervals within the deflation basin correlated relatively poorly with wind speed. Studies in the lee of foredunes (Lynch *et al.,* 2009) where flow separation is also prevalent (Jackson *et al.,* 2011), found little correlation between sediment flux and wind speed using averaging times from 5 seconds up to 1 minute. Whilst Davidson-Arnott *et al.,* (2012) presented strong correlation, (R2 0.77 – 0.63), between 10 second averages of wind speed and sediment transport intensity on the stoss slope of a foredune, this correlation fell to an R2 value of0.12 at the crest of the dune. Similarly in this investigation the correlation between wind speed and flux was weakest at the crest of the erosional wall (R2 0.23 and 0.16 for 10 second and 1 minute averaging intervals respectively) despite it being the location of the steadiest wind speed and greatest flux throughout the blowout. This may be because the erosional wall crest was located immediately before the depositional lobe where sediment entrained from the deflation basin converges and is ejected from the blowout before becoming deposited. Thus sediment transport at this location is not only initiated by wind-flow at the crest but also throughout the deflation basin. Therefore strongest gusts locally may not correlate with the greatest periods of sediment transport.

Whilst the correlation between wind speed and sediment transport is relatively poor in this study, the correlation does improve with increased averaging interval, consistent with the findings of Davidson-Arnott *et al.*, (2012) on a vegetated foredune. Interestingly, TKE correlates better than wind speed when the averaging interval is increased from 10 seconds to 1 minute. This may be due to wind speed being averaged at 1 minute failing to account for variability in wind speed. This is especially critical in landforms such as blowouts whose airflow dynamics are dominated by topographically generated secondary wind flow structures such as corkscrew vertices (Hesp and Pringle, 2001; Smyth *et al.,* 2012, Jackson *et al.* 2013) and zones of turbulent separated flow (Hugenholtz and Wolfe, 2009; Hesp and Walker, 2012; Smyth *et al.,* 2012; 2013). In cases of highly turbulent flow, TKE may be a better parameter in the prediction of sediment transport at minute scale averaging intervals as it considers the fluctuations of wind speed which occur in a landform where turbulent flow is prevalent or when sediment transport is intermittent.

**6. Conclusion**

Incident wind-flow, 100° oblique to the long axis of a blowout, displayed minimal evidence of becoming steered axis-parallel into the throat and along the axis of the deflation basin. This is similar to the findings of Pease and Gares (2013) but contrary to Hesp and Hyde (2001) who recorded the phenomenon throughout the landform.

Sediment flux rates were spatially variable throughout the deflation basin even at points located less than 0.5 m apart. Sediment flux correlated most poorly with wind flow at the crest of the erosional wall, where the greatest rate of flux was measured.

The negative relationship between wind speed CV and sediment flux indicates that as wind flow increases in variability, sediment flux is reduced. Consequently the highest rates of sediment transport were recorded on the erosional wall crest where flow was compressed and accelerated. In contrast the lowest rates of flux were measured in the deflation basin which during the oblique incident wind was subject to topographic flow steering and deflection.

At an averaging interval of 10 seconds, wind speed correlated best with flux at seven of the eight traps deployed, however, at an averaging interval of 1 minute, TKE correlated better with flux at six of the eight traps. TKE may prove therefore to be a better indicator of sediment transport at minute scale averaging intervals within turbulent wind flow.

Whilst near-surface wind flow measurements on the stoss slope and lee of a dune have many similarities to the separation and acceleration of wind flow over the steep erosional walls of blowouts, sediment flux appears to display much more variability within blowouts.

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Table 1. Wind flow parameters calculated from data averaged at intervals of 10 seconds (n=540) for the reference UA and 5 UAs located in the blowout.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
| **UA** | **Height (m)** | **Mean Wind**  **Speed (m s-1)** | **Wind Speed**  **CV (%)** | **Mean Wind**  **Direction SD (°)** | **Mean**  **TKE (m-2 s-2)** |
| REF | 5.87 | 6.75 | 24 | 13 | 3.02 |
| 1 | 0.50 | 2.45 | 34 | 50 | 1.81 |
| 2 | 0.50 | 2.44 | 46 | 91 | 2.28 |
| 3 | 0.50 | 3.16 | 38 | 85 | 2.56 |
| 4 | 0.50 | 4.25 | 30 | 27 | 2.88 |
| 5 | 0.50 | 5.56 | 28 | 22 | 3.58 |
|  |  |  |  |  |  |

Table 2. 90 minute flux and flow parameters calculated from data averaged at a 10 second interval (n=540)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| Trap | Av Wind Speed (m s¯¹) | Wind Speed CV (%) | Flux (g m¯¹ min) | AP |
| 1W | 2.45 | 34 | 7.20 | 0.42 |
| 1E | 3.96 | 0.60 |
| 2W | 2.44 | 46 | 5.51 | 0.67 |
| 2E | 4.17 | 0.67 |
| 3W | 3.16 | 38 | 13.55 | 0.84 |
| 3E | 8.19 | 0.80 |
| 4 | 4.26 | 30 | 23.17 | 0.77 |
| 5 | 5.56 | 28 | 30.17 | 0.87 |

Table 3. Linear regression coefficients for sediment flux rate with wind speed and TKE calculated using 10 s and 1 minute averaged data. All the R2 values are statistically significant exceeding the 99.9% confidence threshold level.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Trap** | 10 s averaged data | | 1 min averaged data | |
| **Wind Speed** | **TKE** | **Wind Speed** | **TKE** |
| 1W | 0.25 | 0.17 | 0.28 | 0.57 |
| 1E | 0.25 | 0.19 | 0.27 | 0.53 |
| 2W | 0.40 | 0.23 | 0.57 | 0.69 |
| 2E | 0.50 | 0.27 | 0.50 | 0.57 |
| 3W | 0.53 | 0.46 | 0.66 | 0.48 |
| 3E | 0.31 | 0.29 | 0.42 | 0.44 |
| 4 | 0.47 | 0.36 | 0.63 | 0.61 |
| 5 | 0.23 | 0.25 | 0.16 | 0.23 |