THE EAST SANDS, ST ANDREWS: BEACH DYNAMICS, HARBOUR DEVELOPMENT AND MAJOR SHIPWRECKS

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The East Sands, St. Andrews: Beach Dynamics, Harbour Development and Major Shipwrecks

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Declaration

I, Pauline Blake-Johnston, hereby certify that this thesis, which is approximately ..40,000...... words in length, has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

Date: 21st January 2005

Signature of Candidate:

I was admitted as a research student in April 2001 and as a candidate for the degree of Research Science M.Phil in Geography (Science); the higher study for which this is a record was carried out in the University of St. Andrews between 2001 and 2004.

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I hereby certify that the candidate had fulfilled the conditions of the resolution and Regulations appropriate for the degree of M.Phil in the University of St. Andrews and that the candidate is qualified to submit this thesis in application for that degree.

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Acknowledgements

For anyone, the test that is any piece of postgraduate research is long and arduous, and I can say with assurance that my experience was absolutely no different. Of course there are people to recognise and thank for their contributions, for no matter how much we like to think our work is solely our own, it simply isn't. We gain help on the way and without the following people this piece would never have been formalised, let alone finished.

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And so here it is, my thesis. To be read - if I'm lucky - but no doubt forgotten, by a whole host of future students........ach well, them's the breaks!

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Abstract

The coastline is a dynamic and constantly changing environment with processes that continually work and modify the coastal margin.

This research was initiated in an attempt to understand the changes along the coastline at the East Sands, St Andrews. Fundamental to this is the examination of the shore profile: a vertical section along a line drawn perpendicular to the shore.

Sometimes known as a 'profile of equilibrium', this is where all parts of the beach are adjusted to the prevailing conditions of wave intensity, in particular storm waves, and longshore currents. Combining what is learned from such a profile with information about the forces acting parallel to the shore, it is possible to construct a three-dimensional picture of coastal activities.

The project aims to measure the changing profile of the East Sands using GPS Surveying equipment. Collation of this data will allow the current coastline to be compared with a past database of East Sands profile results, in order to create a historical archive of the dynamics of the site over the last 2 years. Further, the profile changes will be compared to local weather records, in an attempt to reconcile known seasonal fluctuations of a coastal system to that of the changing profile. These ongoing processes have been further complicated with the construction of both a jetty and seawall. This adds a new dimension to the variations within the system, and ultimately the beach profile.

Chapter 1

Introduction

Any coastline is the position at which the land, sea and atmosphere meet. Many factors, and their interactions, contribute to the workings of that particular coast, resulting in a dynamic and challenging research area. Coastlines are also the location of most major human settlements around the globe, almost half of the world's population live at the coast, and consequently people interfere with nature, usually with unforeseen and unwanted consequences (Pethick, 1984).

It is vital that as our populations and settlements on the coastline grow, we must gain a better understanding of the dynamics of coastal systems as a whole (Viles & Spencer, 1995). The coastal zone is seen by many as a common resource, available to all, but a modicum of sensible resource allocation and contemporary research will help to better understand natural coastal processes, so that we may better appreciate and manage this unique environment without irrevocable damage. As coasts are not static environments, erosion, sediment transport, deposition, tides, currents and climate all contribute to direct changes in the morphology of a coastline. All natural coastal operations are interlinked in some way and understanding the processes and products of this interaction is rarely simple. It is, therefore, advantageous to adopt a holistic or 'systems' approach to any coastal research in order to understand any environment successfully. To do this effectively equal consideration must be given to the forces that drive the coastal processes - waves, tides and currents - examination must also be of coastal landform development - through the transport of sediments - then application of this knowledge must be extended in order to understand a working coastline. With frequent alteration, it is possible to surmise that coastal changes are principally caused by changes in energy conditions within the system. For example, wave conditions, and therefore energy, will increase during storm weather. The morphology of the coast will then respond to these changes in energy because it aims to exist in a state of equilibrium (Pethick, 1984).

Sandy beaches are the most familiar of all coastal landforms. They are one of the most used, yet most abused, natural resources available to man and it has become clear that research needs to clarify how the coastline works so that we may use it, yet live harmoniously on the coast (Viles & Spencer, 1995).

To attempt to understand changes and morphology along any beach, it is vital to look at the movement of sediments through study of the shore/beach profile. Essentially this is a vertical section of the beach taken along a straight line that is drawn perpendicular to the shore (Dutch et al, 1998, Skinner & Porter, 2000). Continuous examination of such profiles, assimilated with information about the forces acting on that shoreline, will allow the construction of a three-dimensional picture of any study site (Skinner & Porter, 2000), ultimately enabling reconstruction of past events and assisting with future predictions of patterns. The profile or cross-section of a beach at any time is determined largely by wave conditions during the preceding period (Bird, 1969).

The morphology of a profile can be infinitely variable, but in general there are two types recognised that reflect important process variations (Pethick, 1984). These have been given such titles as 'summer/winter' profiles, (King, 1972, Dutch et al 1998), 'storm/normal' profiles (Johnson, 1949) and 'storm/swell' profiles (Komar, 1976).

They are so-called to indicate that the profiles will have two distinct forms resulting from seasonality, not by their morphological differences to each other (Pethick, 1984).

The study site, the St. Andrews East Sands, was chosen as a comprehensive area to research the system morphodynamics of a nearshore environment, in effect, investigate the response of the physical environment to its' external forces. It is an attempt to increase understanding of the factors that are shaping the beach, but also to enable the prediction of possible consequences of anthropogenic change i.e. the construction of a harbour, a pier, breakwaters, seawalls and a jetty. The East Sands are a vital part of the town, for both its population and visiting tourists. It is important then, to understand what's happening to the beach so it can be maintained it in the long term both as a resource and source of revenue for the town of St. Andrews.

Thus, to derive a full picture of the workings of this particular section of coastline, the research was structured to look in depth at several individual factors

- The local characteristics of the East Sands, distinguishing the exact processes at work in the study site
- The historic development of the East Sands, as a harbour and a beach
- The collation of beach profile data, cross-referenced with climate patterns

Consolidating these vital pieces of information will make it possible to piece together the ongoing processes that shape the coast, and what we must understand in order to maintain the East Sands as a useable resource.

Chapter 2

Local Physical and Environmental Characteristics of the Study Site

In order to gain a full understanding of the study site it is vital to place it both geographically and historically. By detailing locality, geology, geomorphology and climatology it is possible to gain a conclusive picture of the local physical and environmental characteristics that have, and are, shaping the East Sands.

2.1 Locality

The study site, The East Sands, are part of the coastal zone of NE Fife, on the East Coast of Scotland, with the Sands themselves located on the eastern side of the town of St. Andrews, and are just one of the town's three beaches. Fife's coastline extends from Newburgh to Kincardine for some 170km, and forms two thirds of the Kingdom's boundary (Ritchie, 1979, Ritchie & Mather 1984)

The Sands are part of the bigger St. Andrews Bay, which is a semi-circular embayment, 27 km wide, and bound by headlands to the north, by Deil's Head, and to the south, by Fife Ness (Ritchie & Mather, 1984). Water depth in St. Andrews bay ranges from 3.2m to 11.2m below Admiralty Chart Datum (Fugro, 1995).

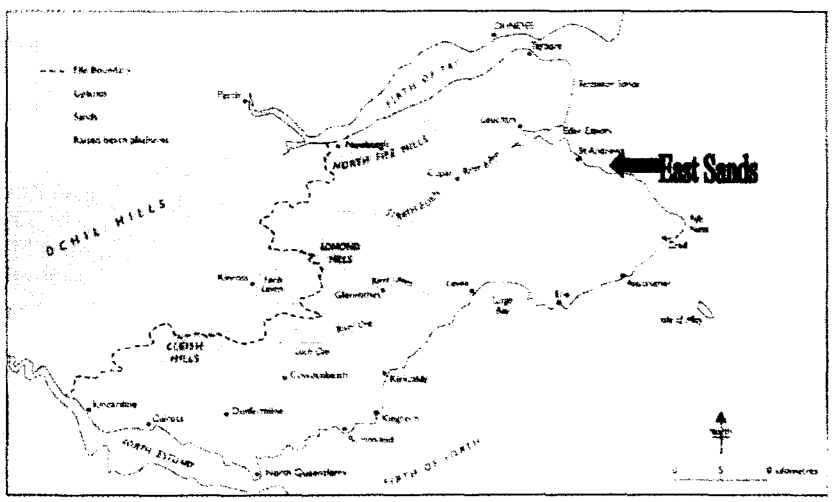


Figure 2.1 The County of Fife, (Omand 2000)

Two estuaries are present at the head of St. Andrews Bay, those of the rivers Tay and Eden. The County of Fife is drained by three main rivers the River Eden (31km), the

River Leven (21km) and the River Ore (19km long), all have a large number of tributaries, and all flow eastwards (Figure 2.1).

The East Sands themselves, are about 500m long, face east, and are bounded at both the north and south ends (Ritchie, 1979). The northern boundary is at the low stonewalls of the pier breakwaters, protecting the entrance to the river basin harbour at the outlet of the Kinness Burn (Plate 2.1 and 2.2).

Plate 2.1: Aerial View of the Pier & Breakwaters

Plate 2.2: Southern End of the East Sands

To the south the land rises relatively steeply to the cliff top plateau area of the Kinkell Braes – upon which the highly popular Kinkell Caravan Site is situated. A predominantly sandstone rock platform lies at the base of the 15-20m high Kinkell cliffs (Maritime Fife, 1997).

Plate 2.3: Shore Platform looking North towards St. Andrews

This gently seaward sloping shore platform is present only to the south of the East Sands where it extends seawards from the base of the Kinkell cliffs, to about 1 m above low water (Plate 2.3). Its presence at the base of the cliffs affords them a level of protection from wave energy, which is partly expended as it crosses the platform, so that wave action becomes limited as a process undermining the cliffs. The shore platform found at the East Sands is an Intertidal Platform or Wave Cut Platform. It is continually subject to such processes as salt weathering, alternate wetting and drying (leading to potential slope failure), water level weathering, solution, frost weather and processes of erosion such as quarrying, hydraulic action, pneumatic action and abrasion (Summerfield, 1991). Shore platforms are seldom horizontal and often possesses a gentle seaward slope of 3 degrees (Pethick, 1984), as does the shore platform of the Kinkell cliffs in this instance. The morphology of the St. Andrews rock platform suggests the processes likely to be responsible for its evolution are geological in nature. Lack of debris on the platform itself and limited undercutting of the backing cliffs all suggest slow rates of present day modification, and wave activity, tidal range and chemical weathering of the area are the primary forces responsible for the slow and continued development of the platform today.

Immediately inland from the East Sands itself, there is a low, but level, raised beach surface roughly 5-7m above sea level (Maritime Fife, 1997). Originally farmland, latterly it has been developed and now houses the East Sands Leisure Center (Plate 2.4), the Gatty Marine laboratory of the University of St. Andrews (Plate 2.5), St. Andrews University Student housing (Plate 2.6), and a privately owned housing estate.

Plate 2.4: East Sand Leisure Center

Plate 2.5: Gatty Marine Lab

Plate 2.6: University Housing

The north part of the beach sees the outlet of the Kinness Burn, with its narrow harbour basin, run parallel to the coastline. The bank sloping down to the river is steep, and the intervening slip of land is no more than 70m wide (Ritchie, 1979), and is a low, gently domed sand ridge 4-6m high (Plate 2.7). Most of this area is open grassland, with a play area and small, rarely used putting green (Plate 2.8).

Plate: 2.7: Aerial of Kinnessburn outlet

Plate 2.8: Play Area and Putting Green

The East Sands, due to the dynamics of this particular coastal cell, is a relatively sheltered beach, and aerial photography illustrates the expected sandbars offshore (Plate 2.9). The immediate offshore gradient is slight and wave energy is largely absorbed through the effects of shoaling.

Plate: 2.9: Aerial of low gradient of East Sands, and sandbars partially visible in offshore zone

The beach terminates against a low near-vertical sea wall, 1m -1.5m high, primarily constructed to defend the beach against erosion, and preserve it as a tourist attraction. The sea defence wall consists of three separate sections of hard engineering ploys, theoretically designed to retain the sediments on the East Sands. The south portion is a concrete wall (Plate 2.10); the central, a section of a steel sheet pile construction

(Plate 2.11), and to the north there is another concrete wall, lower but this time with a lip (Plate 2.12). This last section of wall continues to the lower pier and breakwater structures at the south entrance to the harbour.

Plate 2.10: The South Seawall

Plate 2.11: The Central Seawall

Plate 2.12: The North Seawall

Coastal defence at the East Sands has been designed to afford the coast protection and act as a barrier to storm surges/flooding. The seawalls work by preventing the erosion of the land and encroachment by the sea beyond a fixed point, whilst also protecting the adjacent low-lying land from flooding by the sea. In particular they serve to protect the property and industrial development in this part of the town. Storm surges, particularly when combined with high spring tides and/or heavy rain, are a major flooding threat to low-lying coastal areas and the East Sands can, and has, experienced this phenomenon. The notion of coastal defence began as early as 1877 (Moore, 1992), when the St. Andrews Town Council commissioned a sea wall to be built, to prevent the continual breakthrough of the Kinness Burn over the East Bents with almost every storm that hit the area. Indeed The Royal Commission on Coast Erosion (1911) reported that

'The erosion [on the East Sands] has been going for a long time, and within the last 10 years the coastline appears to have receded by about 20 or 30 feet [6-9m]. The erosion principally affects the property belonging to the University of St. Andrews, and it appears to have been accelerated by the removal of materials under the authority of the Corporation – who claim the foreshore – from the beach. The representative of the Corporation who gave evidence admitted that the removal greatly assisted the erosion'

Thus began a long and continual program of coastal protection in and around East Sands.

About 200m south of the harbour there is a slipway and jetty giving access to a small partly surfaced car park, in the front of Gatty Marine Laboratory of the University of St. Andrews. This area is known as the East Bents (Plate 2.13). The jetty was constructed and is owned by the St. Andrews Sailing club, which owns the building directly behind it. This is a particularly busy section of the East Sands as it provides the main vehicular access to the beach area, a play park and café are also situated here which tends to be a natural congregating point for visitors (Plate 2.14).

Plate 2.13: The East Bents

Plate 2.14: The Sailing Club Jetty

Behind the sea wall, but separated from it by a 5-10m wide sloping grass bank, there is a continuous, surfaced pathway which extends from the harbour bridge along the length of the beach, up to caravan park and beyond, where it becomes the North East Fife Coastal Footpath (Plate 2.15). The path is heavily used, both by visitors, University residents and leisure centre users as access and a thoroughfare. This is a popular beach, as scenic interest is generated by the harbour, the backdrop of the Cathedral ruins and the town to the North (Plate 2.16).

Plate 2.15: The Footpath/Fife Coastal Path

Plate 2.16: The East Sands with the St. Andrews backdrop

2.2 Geology

The underlying geology of the East Sands lies within the larger regional setting of the County of Fife, in Scotland. Fife is bordered to the northeast by the southern tip of the Highlands, as well as being bordered in the southeast by the Sidlaw Hills, which are separated from the Ochil Hills in the southwest of the county (Figure 2.1).

Era	System	Group etc	Max. thickness m's	Igneous Rocks Eruptive	Intrusive	Age in My
Quaternary	-	Glacial, fluvioglacial and marine	60+	-	-	2
Tertiary & Mesozoic	-	-	-	-	-	225
	Permian	-	-	-	Necks	286
	Carboniferous	Coal Measures	1100+		Quartz-doleraite sills & dykes	
		Passage Formation	270+	minor		
		Upper Limestone Formation	335+	intermittent	Olivine-dolerite teschenite sills	
Upper Palaeozoic		Limestone Coal Formation	430	volcanoes		
		Lower Limestone Formation	175		Necks	
		Stathclyde Group	2000	Burntisland volcanoes		
		Inverclyde Group	180+	-		
						360
	Devonian	Upper old Red Sandstone	700±	-	-	
		Lower Old Red Sandstone	7000	Ochil, Fife, Sidlaw, Montraose volcanics	Dundee sills N.Fife	
						410
	Silurian	Stonehaven Gp	1500	-	Newer Granites	
						-
Lower Palaeozoic	Ordivician	Highland Border Complex	?	spilitic lavas	serpentinite	
	Cambrain				-	
		-	-			590
Pre-Cambrain	-	Daldrian – Southern Highland Group	2000+	-	Epidiorites	

Figure 2.2: Partial Geological Timescale, (MacGregor, 1996)

The East Sands, and the immediate St. Andrews coastline, is formed from some of the oldest sedimentary rocks on the East Coast of Britain. There is evidence of both igneous and sedimentary rocks present, with the last glacial, and post-glacial, events having left drift deposits.

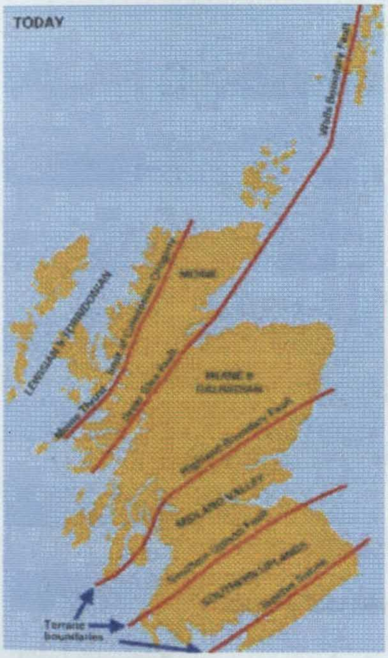


Figure 2.3: Major Fault Lines in Scotland, (SNH, 1999)

The Midland Valley of Scotland is bounded in the north by the Highland Boundary Fault and to the south by the Southern Uplands Fault (Figure 2.3). Fife lies in the eastern part of the Midland Valley, an area principally underlain by Upper Palaeozoic rocks of the Devonian and Carboniferous ages (Figure 2.2).

The Ochils and North Fife Hills, which trend ENE-WSW, are mainly lavas of Lower Devonian Age. These resistant volcanic rocks are overlain by the relatively soft Upper Old Red Sandstone sediments which form the lowlands of Stratheden.

The hills of central Fife, which are south of Stratheden, are largely formed on the major Midland Valley sill of quartz, dolerite and scattered volcanic rocks of the Permo-Carboniferous age, as in the East and West Lomond Hills and many centres throughout the south of the region. These igneous masses are intruded into Carboniferous sediments, which range from early Sandstone-rich assemblages to younger coal-bearing deposits of cyclic origin (MacGregor, 1996). The coal-bearing Carboniferous rocks are folded into complex synclinal and anticlinal structures which have been intensely faulted in most parts of the area.

Glacial tills and late-glacial sands and gravels are widespread in Fife in many areas (Figure 2.4). The over-riding Pleistocene ice sheets served to remove most of the irregular landscape features, producing the generally smooth and rounded geomorphological patterns of today.

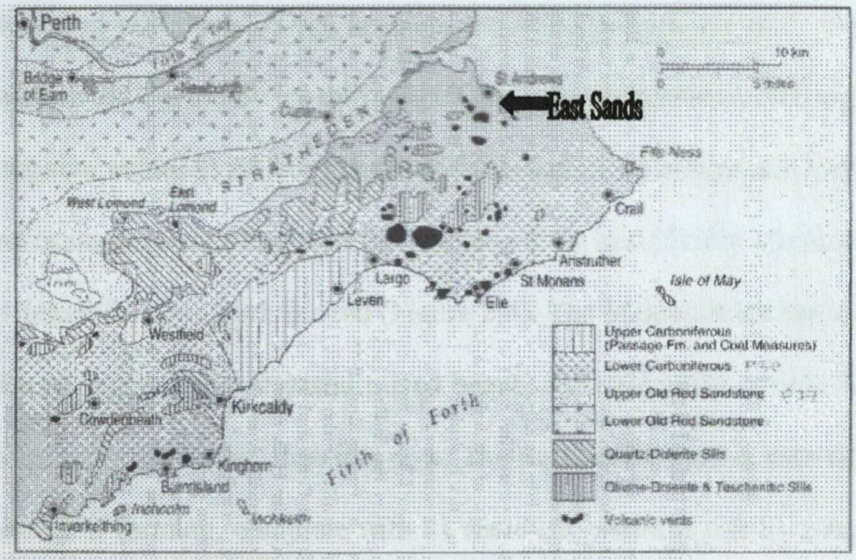


Figure 2.4: Simplified Geological Map of Fife, MacGregor 1996

The immediate area of the study site itself, exhibits a variety of geological phenomena, including common sedimentary rocks – such as sandstone and shale in particular, but and also mudstone and limestone (Figure 2.5).

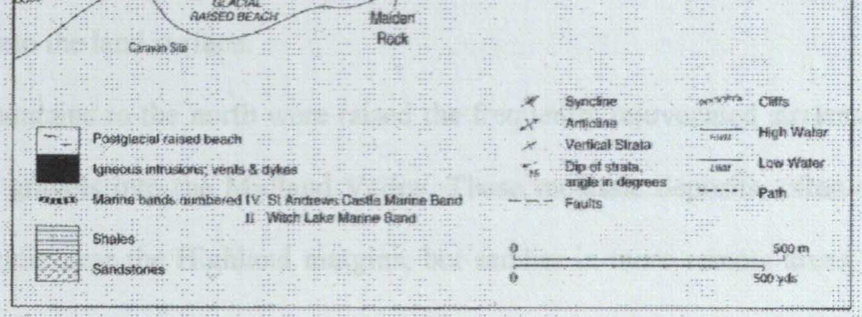


Figure 2.5: The Geology of the Kinkell Braes, MacGregor, 1996

The geological formations of the East Sands area belong to the Strathclyde Group of the Carboniferous System and show signs of having accumulated under shallow, freshwater or deltaic conditions with occasional marine incursions. Igneous rocks, though present, are rare and highly altered. Recent features are also present, such as the late-glacial and postglacial raised beaches, the Maiden Rock sea stack and erratic blocks of dolerite left behind by ice during the Quaternary glaciation of the region.

There is extensive evidence of late glacial raised beaches, all around the East Sands, with the best examples being found on the Kinkell Cliffs, specifically where the lower part of the Kinkell Caravan Park is sited (Figure 2.4). The Maiden Rock sea stack also stands on the remnant of a postglacial raised beach, and dates from a time when the sea level stood some 4m higher than it is now. The East Sands itself is seen as a much younger beach still forming, complete with its wave-cut platform cutting across rocks of varying hardness at the shoreline.

Towards the end of the Silurian period (around 420 Ma) the Iapetus Ocean, whose northerly margins lay in the Southern Uplands, entered its final stage of closure. Associated with plate collision and northward subduction, this created the structures of the Caledonian orogeny. These served to uplift the Dalradian rocks of the Grampians and also generated suites of intrusive igneous rocks within the Highlands. Along the fringes of the Highlands, and within the Midland Valley, subduction-associated extensive volcanic rocks, principally andesite or basaltic lavas, were released onto the land surface.

As the mountains to the north were raised the frequently rejuvenated streams carried sands and gravels into the Midland Valley. These molassic deposits, often coarsely conglomeratic near the Highland margins, but sandier in more remote areas, such as Fife, formed the rocks of the Lower Old Red Sandstone. Of Lower Devonian age, and contemporaneous with the volcanic eruptions, these sediments are the earlier deposits along the northern most fringes of Fife, beside the present day Tay Estuary.

The Lower Old Red Sandstone, sediments and volcanic rocks, of Eastern Scotland are estimated to reach maximal thickness of 9km. The sediments are largely alternating red and brown sandstones, reddish mudstones with mud cracks and burrows (MacGregor, 1996). Whereas in the western section of the Ochil Hills considerable thickness of pyroclastic rocks occur among the lavas, in the North Fife Hills the volcanic rocks are principally of lavas. Andesite and basalt are the main rock types, although pyroclastics are present around volcanic necks as near as Auchtermuchty. According the MacGregor (1996) the greatest thickness of the Lower Old Red Sandstone volcanics is 2400m.

Compositionally they resemble the Lower Old Red Sandstone lavas, where olivine-dolerites correspond to basalts, the basic porphyrites correspond to the andesites and the porphyrites to the felsites. This chemical similarity between lavas and minor intrusions has led to the conclusion that they are of the same general age as the Lower Old Red Sandstone (MacGregor, 1996).

- **The Devonian**

The middle Devonian is nowhere represented in Fife. It was a period of further uplift in the Highlands while active erosion took place in the molassic plains of the Lower Old Red Sandstone. Thus, the Upper Devonian deposits, which occupy the floor of Stratheden and the Howe of Fife, nest unconformably upon the Lower Devonian volcanics and sediments.

The Upper Old Red Sandstone extends east to Guardbridge and is readily seen in the lower parts of Dura Den. Above a basal conglomerate bearing a wide variety of rock types, the honey coloured sandstones of the Dura Den – Cupar area are well known for their fossil fish contents. These sandstones, of the Kinneswood formation, are largely fluviatile or estuarine in origin with some wind blown horizons. They are exposed north and west of St. Andrews (Ramsay, 1968).

- **The Carboniferous**

Outcrops of rocks belonging to the Carboniferous System lie mainly southeast of a line extending from Guardbridge to the south side of Loch Leven – and so includes the study site of the East Sands. Within this area all the major units of the Carboniferous System are represented.

The outcrop distribution is partially controlled by two large complimentary structures trending N-S: the Leven Syncline and the Burntisland Anticline. The Carboniferous rocks are subdivided as shown in Figure 2.6.

Sub-system	Series	Stage	Old Classification		New Classification	Formations
300my		D	Upper Coal Measures			
		C				
	Westphalian	B	Middle Coal Measures			
		A	Lower Coal Measures			
310my			Passage Group		Passage Formation	
	Namurian		Upper Limestone Gp		Upper Limestone Formation	
			Limestone Coal Gp		Limestone Coal Formation	
325my						
		Brigantain	Lower Limestone Gp		Lower Limestone Formation	St. Monans Brecciated Lst
	Visean		Upper Oil-Shale Group			
				Calciferous	Strathclyde Group	
			Lower Oil-Shale Group			
		Asbian		Sandstone		
			Cement-Stone Group	Measures		
		Holkerian Arundian Chadian			Inverclyde Group	
355my	Tournaisian	Courceyan	Upper Old Red Sandstone		Stratheden Group	Knox-Pulpit Dura Den
	Fammenian					Glenvale Burnside

Figure 2.6: The Carboniferous of Fife, MacGregor, 1996

The early Carboniferous rocks of the Inverclyde and Strathclyde Groups are widely developed in East Fife. Formerly known as the Calciferous Sandstone measures, they were explained by Geikie (1902) and later by Greensmith (1965) and Forsythe & Chisholm (1977). Poorly exposed inland, the rocks are best seen in coastal cliffs to the east of the East Sands. They consist of yellow and reddish sandstones with green and purple marls and rare purple conglomerates with andesite pebbles up to 2cm in a muddy matrix. The andesite pebbles imply ancient erosion of Lower Old Red Sandstone lavas soon after deposition (MacGregor, 1996).

The Strathclyde Group is well exposed in the cliffs at St. Andrews, where thick, pale-coloured grey and white sandstones are interbedded with shales, thin coals and at least one thin limestone. Channel-fill sandstones are often overlain by shales with non-marine bivalve fauna and these, in turn, by marine shales. Seat earths and thin coals cap some of the massive sandstone layers.

The lithology of the Fife Ness Beds, the lowest formation of the Strathclyde Group (site specific to research area), is predominantly of relatively thick, white sandstones interbedded with grey shales and occasional red mudstone. The sandstones from resistant ridges, which stand against erosion and can be followed across the wave-cut platform, whereas the shales and mudstones are normally represented by hollows.

The nature of the Strathclyde Group of sediments indicates deposition under humid, tropical, deltaic, fluvial swamps which were occasionally flooded by the sea, when forest destruction occurred. Channel switching within this delta, in an area of general subsidence and with fluctuations of sea level was characteristic of conditions during deposition of these cyclic assemblages of lower carboniferous sediments (MacGregor, 1996). These provide the foundation of bedrock in the East sands area.

2.3 Offshore Geology

During the Pleistocene the landmass that constitutes the UK, and its surrounding seas, experienced fluctuating sea levels and ice sheets. The seas were crossed on a number of occasions by large ice sheets leaving both glacial till (boulder clay) and glaciomarine muds deposited widely across the sea floor in the St. Andrews Bay region. All are covered by a thin veneer of Holocene sediments. The glacial sediments are all essentially Late Pleistocene in age, deposited mostly during the last ice advance, and comprise either till, pebbly glaciomarine muds or sands interbedded muds and silts (Barne et al, 1997) (Figure 2.7).

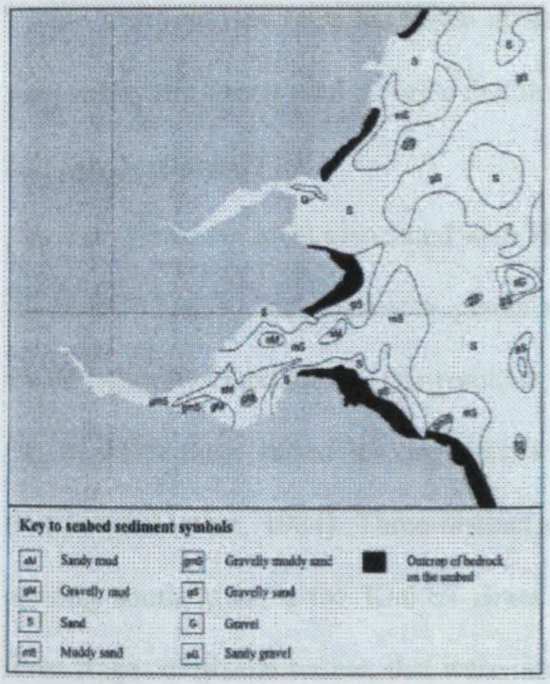


Figure 2.7: Offshore Geology of Fife, (Barnes et al, 1997)

The bedrock beneath St. Andrews Bay is believed to consist of Devonian rocks to the north of the Eden Estuary, and mixed Carboniferous sediments to the south. Characterised by a fairly smooth bottom topography, the seabed slopes down gently from the coast at an overall gradient of 1:170 until a depth of approximately 11m is obtained (Sarrikostis, 1986).

Seabed contours of the Bay run sub-parallel to the coastline except at both the Tay Eden estuary mouths, offshore currents and onshore winds ensure that submarine sand spits and bars are continually forming e.g. the Tentsmuir sands are still growing, as are the spits of the Abertay Sands and the Gaa Sands, both extending out from the mouth of the River Tay. Extending out from the estuary for 7km they are constantly shifting due to the interplay between sea currents and the significant outflow from the Tay (Ferentinos & McManus, 1981).

The seabed off the south end of the East Sands beach, off the Kinkell cliffs, consists almost entirely of outcropping bedrock, with a relief of up to 2m. Further offshore, approximately 150-200m this rock surface becomes smooth and is overlain by a sand unit up to 3m in thickness (Fugro, 1995).

The whole of the nearshore bed of St. Andrews Bay is comprised recent fine and very fine sands (Al-Washami, 1996). They date from the Quaternary period, and although they conceal most of the 'solid geology' in the Bay, isolated rock outcrops do occur. To the north and east are extensive areas of dune-clean sands and areas of gravel sculpted by the strong tidal currents that flow parallel to the coastline (Fugro, 1995).

2.4 Geomorphology

The changes of sea level associated with Pleistocene glaciation led to the formation of the series of raised beach terraces, plains and associated shoreline which characterise the St. Andrews area today. The resultant morphology is characterised by numerous fragments of these raised beaches with links, dunes and sand spits all in evidence (Ritchie & Mather, 1984). Three distinct raised beach levels can be identified when looking south towards the Kinkell Braes from the East Sands itself. Representing three stages of glacial retreat, that were interrupted by periods of re-advance, they can be identified within the Caravan Park itself at 8m, at the top of the cliffs at 23m and at the first line of caravans at 38m (Robertson & Miller, 1997).

Further information regarding the influence of glaciation on the St. Andrews Bay area, and its shoreline development, is discussed in Chapter 3.

2.5 Climatology

St. Andrews Bay, on the west coast of the North sea, has a record for storminess associated with many shipping disasters. During the 17th to 20th Centuries this was a very busy seaway, and reports of weather conditions, notable storminess, extend back for several centuries and there have been signs of increased storminess since 1950 (Lamb, 1991).

With increased economic activity in the north Sea through shipping, fishing and the oil and gas industries has led to a demand for understanding of the climatology of the sea area.

The temperate, humid climate of the North Sea embraces a prevailing southwesterly wind, which is characteristic of a temperate humid zone (Goldberg, 1971). In all seasons there is a dominance of a westerly wind, which transports the maritime air masses that form over the North Atlantic Ocean. The presence of the wind driven North Atlantic Current in the North Sea, therefore, produces a climate with both distinct high rainfall and high average temperatures (Goldberg, 1971).

Although the prevailing winds are from the southwest, the dominant winds blow from the southeast, and during some winters, such winds blow almost uninterrupted for weeks on end. This variability in the winds, in both direction and strength, is largely the result of the procession of atmospheric disturbances, cyclones and anticyclones and their fronts, that travel west to east in this area. These fronts and their accompanying belts of storms have been observed to 'migrate with the sun', in that they retreat pole ward in summer and advance towards the equator in winter (Lamb, 1953). This results in southwesterly winds prevailing in the winter, and northwesterly winds prevailing over the North Sea in the summer.

St. Andrews experience a characteristic sea breeze wind system during periods of high temperatures inland, when directional changes of wind regularly vary through 180° inside six hours (Lamb, 1991).

2.5 Sediment Supply

The stability of the East Sands is controlled by a complex transfer of sand between the beach itself and offshore sinks and bars. Being relatively sheltered from the dominant southeast waves by the Buddo Ness peninsula, means that the beach is predominantly stable, but can experiences cycles of erosion. Wave refraction still brings waves from the southeast into the East Sands (Sarrikostis, 1986).

The sediment transfer process, where inputs to the beach are balanced by loses from the beach so that a status quo remains, and the beach is in 'equilibrium'. If the inputs and outputs are balanced the form of the coast will remain unaltered, yet in a constant state of movement.

There are three recognised states of equilibrium:

a) **The Steady State Equilibrium** - referring to a situation where variations in energy and morphological response do not deviate too far from the long-term average. For example, along a coast that experiences relatively consistent wave energy conditions, the gradient of the beach may be steeper at certain times of the year, and shallower at other, but the average annual gradient is similar from year to year.

b) **The Meta-Stable Equilibrium** - this exists where an environment switches between two or more states of equilibrium, with the switch stimulated by some sort of trigger. An example of this includes the action of high-energy events, such as storms or tsunami.

c) **The Dynamic Equilibrium** - like meta-stable equilibrium, this too involves a change in equilibrium conditions, but in a much more gradual manner (Pethick, 1984). A good example is the response of coasts to the gradual rise in sea levels experienced through the twentieth century.

Sediment supply and transport is described within the context of 'coastal cells' - these being sections of the coast within which the littoral drift directions of sand and gravel 'bed load' are largely dependent on its surrounding cells. (Ramsay & Brampton, 2000). The coast of Scotland has been divided into eleven major littoral 'cells'. These major cells not only reflect beach sediment units, but also divide the coast into regions where the geology, physical character and orientation are similar. These cells can be quite large, and so a number of 'sub-cells' have also been defined (Figure 2.8)

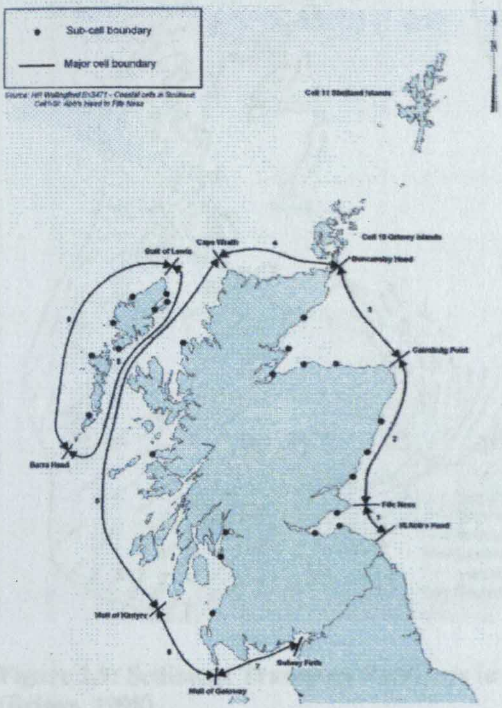


Figure 2.8 Coastal Cells of Scotland, (Fife Council, 1998)

The East Sands, and the dynamics of St. Andrews Bay, falls into **Cell 2: Cairnbulg Point and Fife Ness**, and more specifically Sub Cell 2a: **Diel's Head – Fife Ness**. The coastline in Sub Cell 2a is rocky at both sub-cell boundaries, with the coastal elevation decreasing towards the Firth of Tay in the North, where sandy beaches tend to replace cliffs. Both waves and currents affect sediment transport within this cell.

There is a moderate rate of drift northwards in St. Andrews Bay, towards the Firth of Tay, as wave-induced longshore transport is dominant (Figure 2.9). The boundaries between the sediment cells at St. Andrews Bay are of two main types: Littoral Drift Divides and Sediment Sinks. Littoral Drift Divides usually occur at a point where the orientation of the coast changes abruptly, in this case the rocky headland of Fife Ness. If beach material moves away from such a point, on both sides then that point is the 'drift divide'.

Interfering with the movement of beach sediment on one side of the divide will not cause problems on the other. Sometimes drift can occur without any dramatic change in the orientation of the coast. In this case the position of the drift divide tends to shift from time to time, due to relatively small changes in wave conditions.

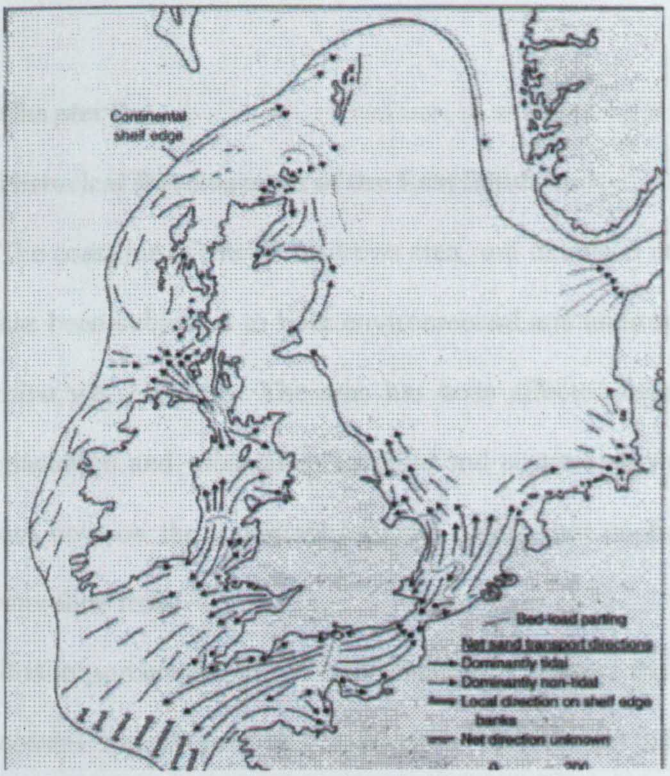


Figure 2.9: Sediment Transport Pathways in the UK, (Briggs, 1998)

There is an obvious tendency for beach erosion near a drift divide, because any mobile sediment will tend to move away from that point. Sediment Sinks – are the points at which sediment transport pathways meet - so that beach material tends to build up.

This happens naturally in such places as well indented bays, in this case the East Sands, but also tidal inlets and estuaries.

The tidal currents in the Bay are responsible for the circulation of sediment and the interaction of sediment movement between sand bars and the beaches. There is onshore movement of sediment within St. Andrews Bay, which is then transported northwards by wave action (Figure 2.9).

Chapter 3

Historical Development of the East Sands

The coastline of the St. Andrews area, and in indeed its wider geographical setting of Fife, has been subjected to both environmental and anthropogenic changes over time to form what we see today. The area has been affected for the most part by the processes of glaciation and subsequent isostatic and eustatic movements, which have left their mark not only on the topography of the region, but on the development of the present day shoreline itself.

It is important to explore these changes, as part of the developments and workings of the coastal system as a whole, in order to ascertain what has happened in the past and therefore what could potentially happen in the future. This will benefit both the short and the long-term management policies for this shoreline.

3.1 Shoreline Development

The growth and decay of the Quaternary Ice Sheets over the last 3 million years have been responsible for major and repeated changes in relative sea levels all over the world (Summerfield, 1991). These impacts are recognised everywhere as groupings of uplifted marine benches, relict beaches and submerged coastlines, which have affected the coastal zone from between 200 meters above present sea level and anything up to 130m below present sea level (Robertson & Miller, 1997) These sea level changes include the combined effects of all factors that may have affected both the level of the oceans, and the levels of the crustal land. Isostasy and eustasy are two physical processes that affect the earth's lithosphere and hydrosphere, involving vertical motions that can be monitored specifically by mean sea level. Eustatic effects account for the changes in the volume of the sea; they can be estimated only from relative sea level data. Isostatic changes are caused predominantly by the radial displacement of the surface of the solid earth, caused by loading and melting of the ice sheets.

As a result of these interactions, it is possible to plot the development of the present day shoreline of the East Sands, from roughly about 80 000 years ago. At this time sea levels around much of the world's coastlines were higher than they are now, but did fall, and remained low during the last glacial phase, until up to around 7 200 years ago – known as the Devensian Period. The scale of this lowering of the sea level has been estimated from the volume of water abstracted to form the late Pleistocene glaciers and ice sheets, which indicate that the sea fell to more than 100 metres below its present level (Skinner & Porter, 2000). As a result of this lowering the worlds continental shelves emerged as wide coastal plains, and actual coastlines advanced towards their outer edges; making the British Isles a peninsula of Western Europe. At the same time the land itself experienced isostatic depression, so that when melting of the ice sheets started, and water returned to the sea, the land remained depressed; this allowed early raised beaches to develop. Later uplift and imbalance between eustatic and isostatic change gave rise to the suite of raised beaches on the Fife coast (Robertson & Miller, 1997).

Reference has been made to the fact that about 18 000 years ago the earth's climate was still very cold, glaciers and ice sheets were close to their maximum extent, and the sea roughly about 140m below its present level (Dutch et al, 1998). The Earth's climate then became warmer, and the ice cover started to melt. As water returned to the oceans there was a worldwide rise of sea level, known as the Late Quaternary marine transgression, roughly between 18 000 and 6 000 years ago. When the rising sea submerged the

Devensian landscapes the continental shelves were inundated and subsequently 'sunken', which then brought the sea to roughly its present day level. The coast of eastern Scotland has also since experienced a degree of uplift, a direct result of isostatic recovery following glaciation.

This has meant that the configuration of St. Andrews Bay has changed a great deal over the last 10 000 years as a result of these changing sea levels (Ferentinos & McManus, 1981). In particular over the last 5 000 years the sea level fell from its postglacial maximum towards the present sea levels we see today, but sea level may well be rising again due to global warming. Glaciation is important also to our understanding of coastal geomorphology in that much of the sediment on the continental shelves are of temperate latitudes, and are glacial in origin.

3.1.1 Glaciation Affecting Fife

Ice sheets covered the whole of Scotland during the glaciation advances of the Pleistocene era. The ice originated in the Perthshire Highlands, and the subsequent melting of the retreating glaciers modified the landscape by cutting meltwater channels and river gorges, but also spread outwash sands and gravels across the entire landmass, characterising the area as having been glaciated.

Effects of the last glaciation can still been seen extensively all over the county of Fife. In particular the topography of the St. Andrews Bay area has been transformed a great deal over the last 10 000 years and again this is largely the result of changing sea levels associated with postglacial adjustments in the area (Omand, 2000). As the entire area was overridden by ice during this glaciation, the effects of the subsequent eustatic and isostatic changes of sea level have left their imprint on the morphology of the area. The geographical distribution of the late glacial (Main Perth) and main post-glacial (Flandrian) shorelines, formed about 13 500 and 6 000 yr BP respectively, confirm that the geometry of the Bay was very different than that of today (Ferentinos & McManus, 1981).

Ice cover, in Fife in particular, was probably at its maximum roughly 18,000 years ago when Scotland was buried under a sheet potentially 2000 meters thick (SNH, 1999), with the thickest ice covering the Rannoch Moor – Loch Lomond area. During this glaciation, the lower reaches of the valley of the River Tay, and northern parts of the Fife, were deepened and the estuary and coastline developed by scouring action of the ice as it advanced eastwards, towards the North Sea. Whilst the ice is moving, i.e. expanding and retreating, loose boulders and rocks were picked up and transported to the base of the ice sheet. Upon melting, these blocks were then deposited over the ground, together with clay and sand particles - this sediment is referred to as till and the subsequent obliterating cover of glacial and fluvioglacial material are known as drift, thought to have formed from the materials carried overland by floating sea ice and icebergs. Evidence of this glaciation is evident all over Fife, as most of the lowland, including the study site, is covered by this blanket of drift and till.

Extensive fluvioglacial deposits, sheets of sand and gravel, also cover much of lowland Fife. These have been, and still are, economically important as sources of building materials, but extensive excavation of them has meant that many of their defining landform features, such as esker ridges, have consequently been destroyed.

Deglaciation allowed the land surface to begin a slow process of rebound, and this gradual rise is still continuing today in Scotland as a whole. Uplift, in conjunction with the retreat stages of the Aberdeen-Lammermuir ice sheet, took place in a series of pulses over the last 13 000 – 14 000 years as the land regained its previous level and the sea again retreated (Omand, 2000). This has given rise to the series of raised beaches around the Fife coast, some of which are quite extensive e.g. Kirkcaldy and St. Andrews through to Leuchars and Tayport. The study site of the East Sands exhibits four distinct levels of raised beach, in particular, where the Kinkell Caravan Park caravans are sited on successive raised beaches terraces.

Glaciation has also provided the majority of the beach material with glacial deposits forming the line of the Kinkell cliffs at the East Sands, and much of the scenery immediately inland from the coast is glacial in origin. Essentially the town of St. Andrews is built on platforms that are associated with lower raised beaches (Robertson & Miller, 1997).

Raised beaches that occupy in NE Fife indicate that the sea level was once relatively higher that it is at the present time, while above 30m the land surface is characterised by mounds of glacial drift, fluvioglacial channels and associated meltwater channels (Robertson & Miller, 1997).

3.1.2 Shoreline Development in St. Andrews Bay

The last 3000-4000 years has seen major changes in the Fife, and also, the St. Andrews Bay shorelines (Ferentinos & McManus, 1981). Historically, St. Andrews Bay shoreline has migrated in response to changing sea level - where rising sea levels saw the shoreline migrate inland, while falling sea levels saw the shoreline moving offshore (Figure 3.1).

It is clear that much of the coastal sediment of St. Andrews Bay derives from the last glaciation that affected the area. At that time vast quantities of sediment were being deposited in both the Firth of Forth and St. Andrews Bay, and so became incorporated

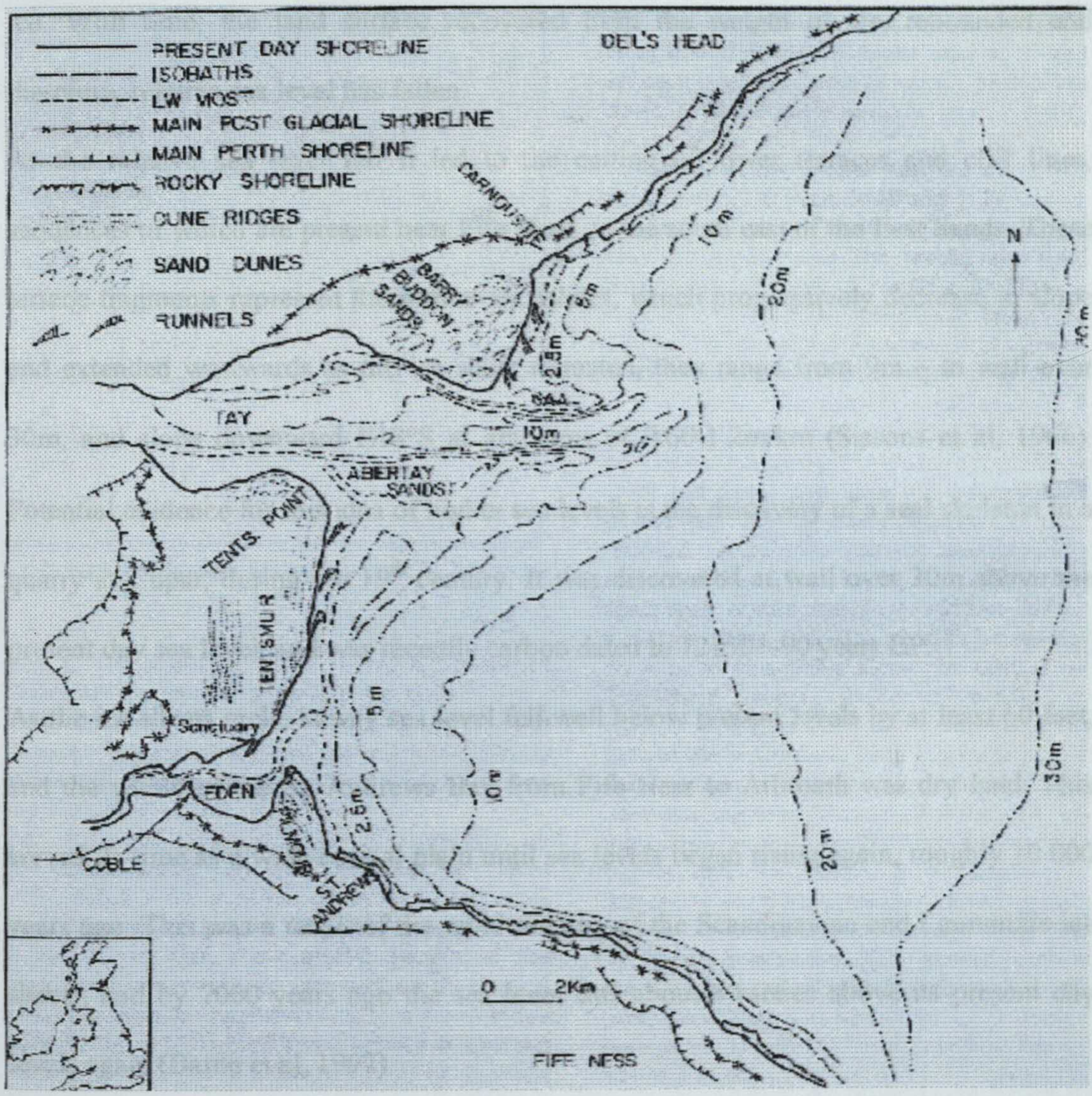


Figure 3.1: Former Shorelines of the St. Andrews Bay Area, (Ferentinos & McManus, 1981)

into local shoreline deposits. Relative sea levels at this time were much higher than at present, estimated at some 30 meters above the current levels, and were resultant of two main processes. Firstly, as mentioned previously, this worldwide adjustment of the oceans following the melting of the last ice sheets, and secondly, the depression of the entire study site due to the weight of the ice sheets covering the land. Thus, in Fife, as the ice sheets withdrew, seawater invaded the low-lying land, as it had been depressed by the ice. With time, the land surface recovered from the weight of ice, rebounded and therefore, relative sea level has fallen.

As the relative sea level fell it led to the cutting of lower terraces and cliff lines, sequences of which are present near Fife Ness, to the south east of the East Sands. These terrace fragments represent the former shorelines, which progressively decrease in slope and extended westwards as the ice sheet retreated, they range from 9m – to well over 30m, and slope downward E18°S at gradients of 0.60-1.2m/km (Sissons et al, 1966). Potential evidence for this idea of higher sea levels is the discovery of a seal skeleton in a quarry at Cupar, during the 19th century. It was discovered at well over 30m above the present day sea level, and was recently carbon dated to 12150+-90 years BP.

As the ice sheets melted away sea level fell well below present levels by at least 60 feet, and the whole of the St. Andrews Bay from Fife Ness to Arbroath was dry land. This served its time as a wide coastal plain until sea levels began rising again, roughly 10 000 years ago. This was a result of the rapid melting of the Scandinavian and Laurentide ice sheets; and by 7000 years ago the sea level was about 8 metres above its present day levels again (Barne et al, 1997).

After this period, of high sea level, the uplift of the land outstripped the world sea level rise as all the ice sheets melted and so sea level started to fall again. Roughly 3 000 years ago, the sea level was close to its present position and been relatively stable since that time, with perhaps some small fluctuations. Although the uplift of land has continued over time, that rise has stopped for the time being and for at least the last 200 years no real sea level change has been recorded for Fife i.e. Fife is rising at the same rate as the eustatic rise from global warming is raising worldwide sea levels.

At the postglacial maximum of the Devensian era, the shoreline of St. Andrews Bay occupied a position at the cliff line south of the Guardbridge road and adjacent to the St Michaels – Tayport road. Since that time the shoreline has prograded into the Bay some 5 km's (Ferentinos & McManus, 1981). This main postglacial shoreline has been identified at 7.0m -7.5m OD at the point of Fife Ness and 8.30m OD at St. Andrews (Robertson & Miller, 1997). The transgression ended about 5500 BP and since that time the sea level has fallen gradually and intermittently. Isostatic uplift continued after the formation of a Main Postglacial Beach, for at least one lower beach is known at 4m OD at the west side of St. Andrews (Sarrkostis, 1986).

The raised beaches of the study site consist of material ranging from silts and clays, interlayered with shelly sands, to rounded pebbles and cobbles, while the intertidal zone has been left with medium and fine sands with bedrock outcrops breaking the continuity of the beach and the intertidal sediments.

It is possible to look at any changes to the shoreline through photographic evidence. Plates 3.1 – 3.7 have all been taken in the last 150 years and demonstrates that the shoreline has remained intact and in its present form since then. The photographs show that the rock platform is a permanent feature in all the photos, but they also give an insight into what the southern part of the beach must have looked like prior to seawall construction.

Plate 3.1: approx mid 1840's, www.scran.ac.uk

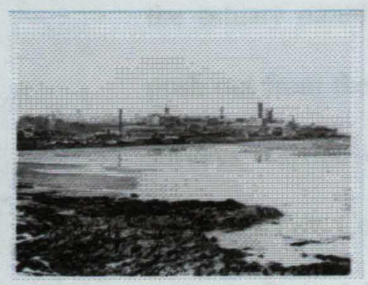


Plate 3.2: approx mid 1850's, Valentine

Plate 3.3: approx late 1850's, Cowie

Plate 3.4: approx 1880's, St. Andrews Preservation Trust

Plate 3.5: approx early 1900's, St. Andrews Preservation Trust

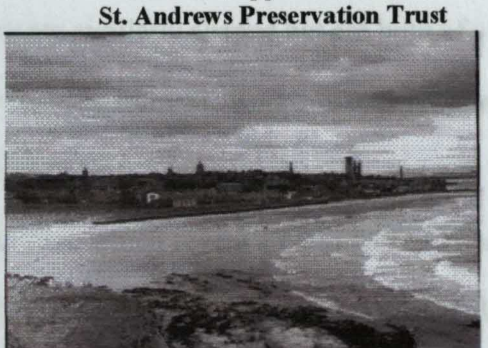


Plate 3.6: approx 1940/50's, St. Andrews Preservation Trust, N.B. construction of the central seawall

Plate 3.7: approx 1950's, Valentine

Within the study site itself, the postglacial and present day sediments can be said to form three distinct geomorphological units which have further influenced the topography of the region.

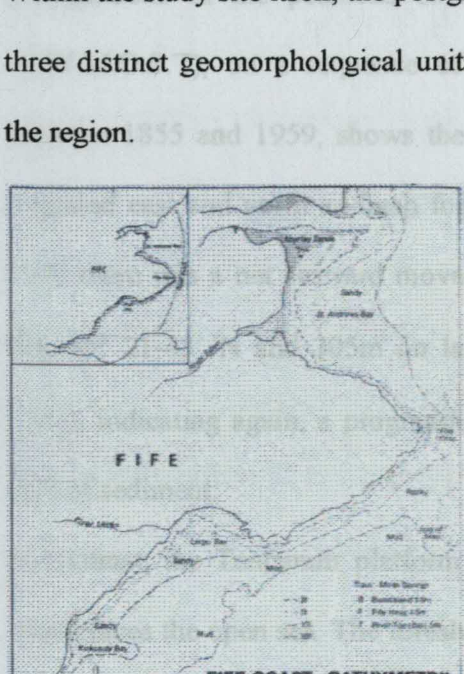


Figure 3.2: Fife's Offshore Bathymetry, (Barnes et al, 1997)

The immediate offshore zone is characterised by a smooth bottom topography, where the contours of the sea floor run parallel to the coastline except at the estuary mouths, here the 'ebb-delta' deposits push out from the coast (Figure 3.2). Geophysical surveys, carried out by the company Fugro on behalf of Fife Council, reveal the existence of a major 'reflector', beneath the entire sublittoral zone of the study site, sitting roughly at 3-4m below the seabed.

A series of boreholes drilled, revealed this reflector, and another at about 20-25m below the sea floor beneath the southern part of St. Andrews Bay, to be the interface between modern and postglacial deposits and glacial tills layers.

The present and postglacial beaches of the study site can be divided into two main 'units' of activity, the Pilmour-Coble sand spits and the Tentsmuir Platform. The Pilmour-Coble spits are similarly shaped but are both of a differing scale. The Pilmour Spit extends 4 km northwards from St. Andrews and is formed at an abrupt change in the direction of the old cliff line. The backshore of the spit consists of foredunes running parallel to the coastline, which reveal a north and eastward growth pattern of the spit. In comparison the Coble sand spit is only 1 km in length, also extends northwards from that change in the trend of the former coastline. This seems to be a relic probably formed during higher sea level (Ferrentinos & McManus, 1981).

Comparisons of the positions of the High Water Mark of Ordinary Spring Tides (H.W.M.O.S.T), on a sequence of 1-10,560 scale ordnance survey maps published between 1855 and 1959, shows the seaward margin of the Pilmour sand spit to have migrated east and north as fresh foredunes became attached since 1855. From 1885 to 1959 there was a net seaward movement of the H.W.M.O.S.T by 490m on the latitude line 56° 21-45' N and 305m on latitude line 56° 21-30'N (Ferrentinos & McManus, 1981), indicating again, a prograding growth of the spit and highlighting a northwards drift of sediment.

In contrast, the Tentsmuir platform is a long, straight beach roughly 8 km in length, which faces the open sea. The foreshore is dominated by a 'ridge and runnel' topography with the runnels facing in a northeasterly direction, while the backshore is dominated by foredunes running parallel to the present shoreline. Boreholes and seismic refraction surveys show that both the postglacial and modern deposits are about 18m thick, which increases towards Tentsmuir Point. These deposits vary from silts and clays resting on a peat layer, that characterises sheltered areas, to sands resting on bedrock or till, characterising more exposed areas.

The variation in the H.W.M.O.S.T. suggests that between 1854 and 1972 uninterrupted net seaward accretion occurred along the central and northern segments of the beach, with the rate increasing on the northern parts of the spit. However, in the southern part of the Tentsmuir shoreline erosion began after 1895.

These particular accretion patterns at the Tentsmuir beach were first studied by the Royal Commission on Coastal Erosion 1911. The Commission's studies found that between the years of 1855 and 1895, 534 acres of beach sediment were gained here, while only 23 acres were lost. Ferentinos & McManus (1981) confirmed and measured …….. of this trend, using 'anti-tank blocks' constructed during World War II. Placed at the H.W.M.O.S.T in 1941, many of the blocks have since been exhumed, …….. indicating early burial followed in the 1960's to 1980's. The northern segment of the beach, in contrast, show the blocks to be 400m inland with several low foredunes occurring between the actual blocks themselves and the beach.

Ferentinos & McManus (1981) also investigated two ebb-delta complexes that influence sedimentation across the entire head of St. Andrews Bay, which could possibly impact, to some extent, on the study site. Both situated north of the Sands themselves – they are the estuaries of the Tay and the Eden. The Tay's ebb-delta consists of an ebb-dominated channel, two marginal sandbars each with a flood-dominated channel and extensive lobe deposits. In comparison, the morphology of the Eden has been dominated by a northward pattern of longshore drift that has ensured the inlet lies, and migrates, to the north where the delta terminates in a convex easterly facing lobe (Jarvis & Riley, 1987).

The ebb channel of the Tay Estuary is up to 11m deep and has been cut into late glacial clays, shoaling gradually seawards and terminating on the crest of an arc-shaped bar at a height of 6m. Geophysical surveys have shown that at this point, the sand body rests on a flat surface that is the landward extension the littoral zone substrate of St. Andrews Bay. Sediment transport studies suggest the existence of a clockwise residual circulation, allowing growth of these sand deposits on the bars to get to a present day thickness of about 20m.

Although the rivers Tay and Eden carry sediments into the area from their catchments they are unlikely sources for the majority of the sediments that make up the East Sands - Tentsmuir area. The Eden enters St. Andrews Bay directly, but any fluvial sediment migrates north to the head of the Bay, as the catchment area is small, so it is not a huge source of sediment.

3.1.3 Recent Changes in Sea Level

The possibility of global warming, resulting in the warming of the oceans, causing expansion of the water mass together with melting of glaciers, implies rising sea level in this century. Long term records of sea level change, for example the tidal records from Brest and Cherbourg, in France, do show a trend of increasing sea level over the last 150 years, are indicating that the world's ocean levels are on the increase (Smith & Dawson, 1983). Much of this trend appears to be associated with global warming following the

Little Ice Age, which led to maximum glacier positions at the turn of the century in Norway and Svalbard. In the last decade concern has risen as estimates have been made regarding the contribution of anthropogenic activity to that rising sea level trend, distinguishing that particular component from the underlying trends caused by random fluctuations in the record caused by meteorological variations.

Recent records from the inner part of the Firth of Forth appear to show a consistent rising trend, but the evidence from the longer term records compiled at Aberdeen, is that short term fluctuations are not a reliable guide to the over all picture of change (Jardine, 1982). Although many agree that, to some extent, global sea levels are rising as a result of anthropogenic activities the effects of these changes on the coastal zone are by no means clear-cut. Within the coastal environment there are concerns over how these changes will lead to increased erosion in the coastal zone, and when they do, at what rate will they happen.

In order to understand potential impacts of changing sea level it is of value to investigate the longer-term changes that have taken place in the past, specifically those changes since the last glaciation. These changes are important to our understanding of present day processes since they have had major impacts on the budgets of sediment in the coastal zone and the ability of these sediments to freely move along the coastline.

In the past, during periods of higher sea level, sand and gravel sediments accumulated in the present coastal zone in and around the headlands separating the present embayment of the East Sands. These deposits thus formed part of a sediment transport path from one part of the coastline to another. As sea level fell the deposits were depleted at the headlands, which then became barriers to free exchange of sediment from one embayment to another due to the presence of deep water at the headland. Accordingly we have many bays around Scotland that appear to have a fixed budget of sand – in the case of the study site this can participate in the internal movement of sediment within the bay, but if that material is lost to the Bay by offshore movement or extraction, that element of the budget can no longer be replenished by movement of material from adjacent parts of the coast.

And so the shoreline in and around St. Andrews Bay has migrated and developed over time, thanks to the combined influence of glaciation, isostatic and eustatic movements and the continual power of day-to-day coastal processes.

3.2 Anthropogenic Development of the East Sands

The research site of the East Sands not only has experienced 'natural' shoreline changes and land developments, but also has experienced major anthropogenic changes almost from the moment the area was settled. These changes have inadvertently altered parts of the East Bents area, largely due to growing industries within the town. The East Sands, including the East Bents and the Harbour, has always been at the heart of many of the towns industries over the years, and this it has meant that the landscape and geography of the area has changed with it.

3.2.1 St. Andrews Town History

The town of St. Andrews, as it is known today, began life as a Pictish settlement, although there is much historical and archaeological evidence suggesting a sizeable population living hereabouts from mid-Neolithic times. Indeed it is often agreed that the area of North East Fife is thought to be one of the earliest occupied areas in Britain.

St. Andrews has long been recognised as one of the great historical cities of Europe. It became a major place of pilgrimage in Medieval Times, as it was recognised to be the resting place of the relics of Jesus' Apostle, Saint Andrew. It has long been said that the town's ecclesiastical connections began at least as early as 747AD, and by the close of the Middle Ages it was the ecclesiastical and intellectual capital of Scotland and a major centre of both political and economic life in Scotland.

For more than a hundred years St. Andrews has been famed as a holiday resort, not only on account of its golf, but also for its history, scenery, climate and its enviable coastal location, which has played an important, and integral, part in the development of the town.

The environment of St. Andrews is said to be '*... so explicitly individual that visitors are aware of the atmosphere upon entering the town ...*' and it is this that ensures the steady stream of tourism each year, which is vital to the economic sustainability of the town.

The study site itself, the area surrounding the East Sands and harbour, has its own important part to play in the historical development of St. Andrews. It was the site of a distinct part of the towns economic development - the fishing industry - and with that a well developed community all of its own. Indeed it is this development and growth of the industry that shaped the history of the harbour, the East Sands and the surrounding area right up until the present day.

3.2.2 St. Andrews Harbour

There has been a working harbour at St. Andrews since even before medieval times, and although has remained remarkably similar over the years, it did not take its present, recognisable layout until roughly 1900 (Brown, 1987). The earliest known date establishing the harbour's age is 1388, although the first recorded reference to the harbour was in 1222 when it was described in the St. Andrews Town Council records as a 'fishing harbour' (Hay-Fleming, 1910).

In its earliest form the harbour consisted of the unimproved, tidal mouth of the river, the 'Kinness Burn', which formed a natural haven for boats, and was used as such before demand for space and more protection from the ravages of the North Sea led to the start of a long, complex history of continual building and improvement (Lyle, 1997). The harbour appears in the earliest known detailed plan of a harbour in Scotland, in the 'Geddy Plan' of St. Andrews c.1580 (Figure 3.3), illustrating that by the late 16th century the main features of the harbour as we know it today existed i.e. the North Pier – better known as the Long Pier - the Traverse Quay, and the Shore and Shorehead Quays (Brown, 1984).

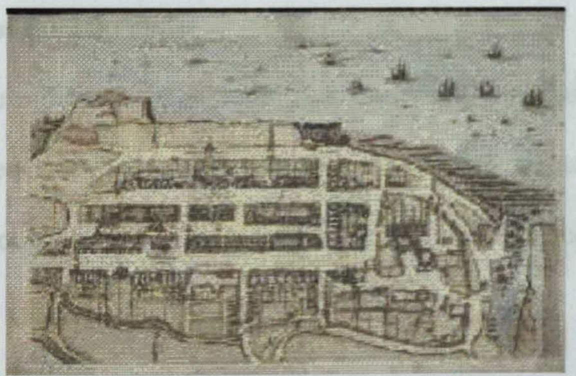


Figure 3.3 The Geddy Plan of St. Andrews, c. 1580, (Reproduction from a St. Andrews Preservation Trust Poster)

The plan, layout and subsequent development of the harbour to its present day structure is largely thanks to the philanthropist, poet and musician George Bruce (1825-1904) who lived in Market Street, who is immortalized in his sponsorship of the Bruce embankment – situated further round the St. Andrews coast, near to the Old Course Golf Course - another example of coastal erosion and protection around the town (Moore, 1992).

Sea fishing was always an important part of St. Andrews economy from long before the Middle Ages, and so the harbour has played an integral part in the development and history of the harbour and it's surrounding area. As noted earlier, pre-Reformation St. Andrews was the ecclesiastical capital of Scotland and as a flourishing center for trade and commerce, was one of the earliest examples of a planned burgh. During the great fifteen day 'Senzie Fair', held every April in the shelter of the great Abbey Wall, there were often 200-300 vessels moored in the harbour, trading in such items as cloth, grain, potatoes, timber, coal, plus a wide variety of other items. The Reformation and the subsequent destruction of the Mediaeval Cathedral, on which so much of St. Andrews wealth had been built, led to a decline in the town's fortunes, and although the 'golden days' of trade and commerce were gone, the harbour remained relatively busy with its prosperous fishing industry.

3.2.3 Development of the Harbour

Essentially St. Andrews harbour is the tidal river mouth of the Kinness Burn (Plate 3.8). It consists of a gated and sheltered inner basin and more exposed outer basin. It is protected by a long outer breakwater, a further groyne and by a long pier (Plates 3.9 & 3.10).

Plate 3.8: Location of Kinnessburn Mouth/Harbour Mouth

Plate 3.9: Long Pier, Cross Pier and Breakwater **Plate 3.10: Kinnessburn Channel in Outer Harbour**

It has a rolling footbridge over the gate chamber of both basins that connects both shores of the harbour – the Shorehead and the East Bents - with each other (Brown, 1984) (Figure 3.4). Being a tidal estuary the harbour is dry at low tide, exposing its considerable mud banks and grounding any vessels.

Plate 3.11: Outer Harbour Mud and Silt Deposits

Plate 3.12: Dry Inner Harbour at Low Tide **Plate 3.13: Grounding of Vessels in Inner Harbour**

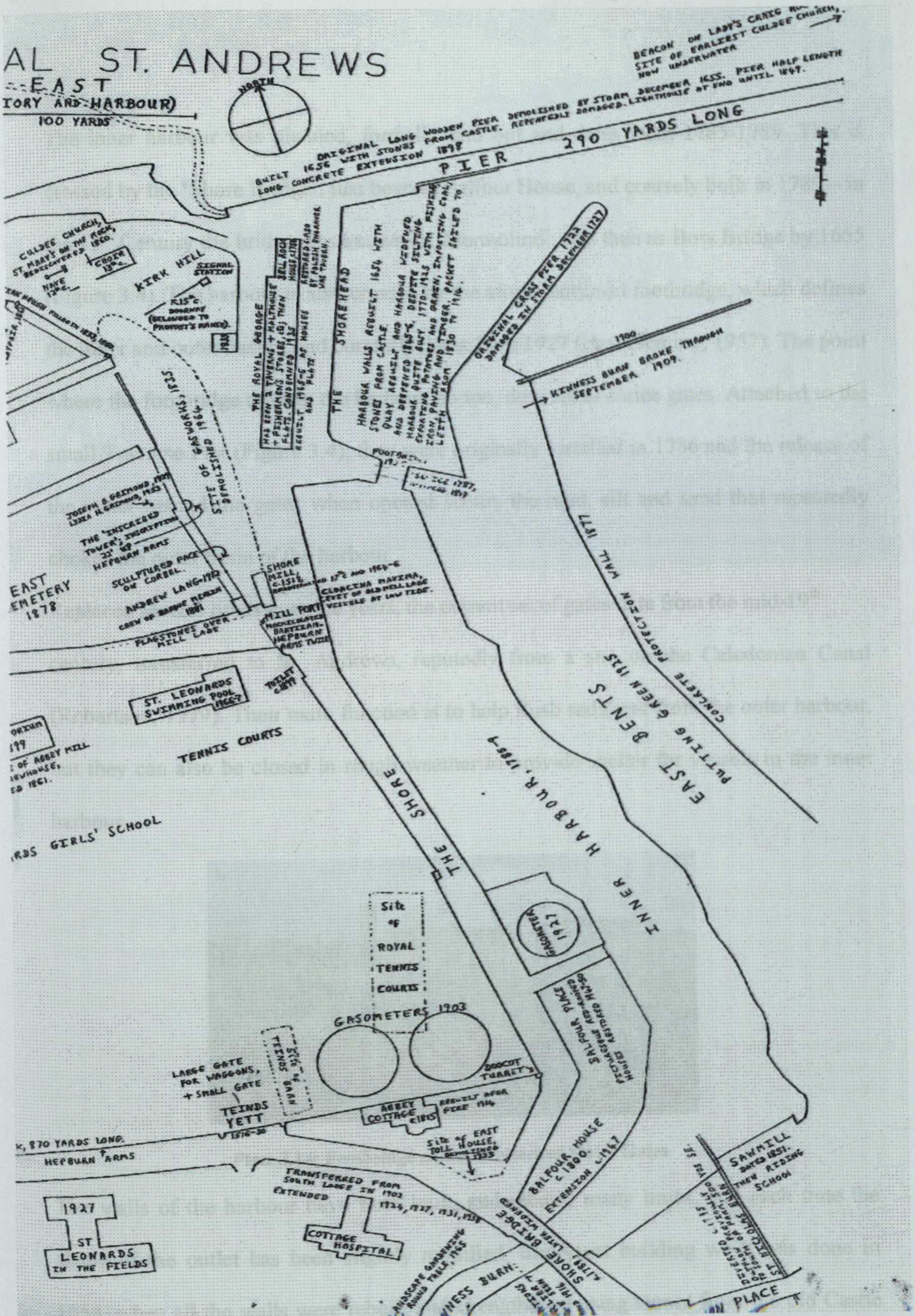


Figure 3.4: Partial Historical Map of East Sands and St. Andrews Harbour Area, (Reproduced from an Estates & Buildings, St. Andrews University, Historical Map, approx 1989)

The inner harbour was planned, formally laid out and dates from 1785-1789. This is crossed by the 'Shore Bridge', just beyond Balfour House, and coarsely built in 1789 – in the 13th Century the bridge was known as 'Stermolind', and then as Bow Bridge by 1655 (Figure 3.4). The harbour is also crossed by the aforementioned footbridge, which defines the inner and outer basins, and currently dates from 1927 (Hay-Fleming, 1957). The point where the footbridge crosses the harbour, so too, do a set of sluice gates. Attached to the small Traverse Pier (Figure 3.4), they were originally installed in 1786 and the release of the water behind the gates when opened scours the mud, silt and sand that repeatedly chokes the outer basin of the harbour.

Replaced several times over the years, the current set of gates date from the mid-19th century, transferred to St. Andrews, reputedly from a site on the Caledonian Canal (Robertson, 1979). Their main function is to help flush sediment from the outer harbour, but they can also be closed in rough weather to provide shelter for vessels in the inner harbour.

Plate 3.14: Footbridge and with attached Sluice Gates

The walls of the harbour have been built, and rebuilt, many times, and each time the shape of the outlet has been slightly modified. Important building work was done in 1654, when all the walls were rebuilt and strengthened using stones from the old Castle ruins. The quays were also rebuilt and the harbour sides again strengthened during 1845-46. It was at this point that both harbour basins were dredged, specifically to deepen them (Moore, 1992). Another call to deepen the harbour was raised in 1872 when the stranding of 15 vessels laden with potatoes and grain, in the upper harbour for nine weeks – caused roughly a £5000 loss for all fishermen, shipping merchants and town merchants alike. The following petition was promptly presented 'To the Magistrates and Town Council of St. Andrews'...

***'...21st February 1872 – Gentlemen – A meeting of the merchants, ship owners, and shipmasters was held this day at the harbour. In consequence of the increasing traffic in shipping potatoes, &c., during the winter season, when it is often impossible for vessels to lieu in the lower harbour, with delay and loss of market from being neaped in the upper one, we have come to the conclusion to memorialse you to improve the harbour ...'*, (Bruce, 1884)**

Despite this continual problem of rapid silting the harbour was at its busiest commercially from 1770-1925, when the large fishing fleet was supplemented by a prosperous cargo trade, for both the exportation and the importation of such items as coal, iron, paving stones and timber.

The harbour was as an important part of the town, and its history, as even the Cathedral and Castle were, and remained so till after the Reformation, when the fortunes of the whole town dwindled greatly. Indeed Thomas Tucker, Cromwell's Commissioner to Scotland, reported in 1655 that

***'...St. Andrews hath formerly been bigger and although sufficiently humbled in the time of intestine troubles, continues still proud in the ruins of her former magnificence ... to this porte and members thereof there are many vessels belonging, which are employed for the carrying of coale and salt outwards and to the coast ...'*, (Brown, 1987).**

3.2.4 Development of the Piers

The most striking features of the harbour are the two piers, the Long Pier – at around 270m - and the Cross Pier – at around 70m (Moore, 1992) (Figure 3.4), which have been part of the layout of the Harbour for centuries. The Geddy Map of St. Andrews (Figure

3.4) also illustrates structures of timber and stone flanking the entrance channel to the harbour and extending inland along the Kinness Burn. Both of these structures have been subjected to much alteration, being frequently reconstructed and repaired over the centuries. The piers would originally have been made out of timber with a stone filling. Recent archaeological investigations indicate that the Long Pier is a dry-stone rubble construction revealing many examples of repairs and a variety of construction techniques. For example, close to the face of the Cross Pier are the remains of several wooden posts embedded in the rock itself, these are thought to be the remains of the original timber and stone pier (Ramshaw, 1993).

The first, and what later became known as the Long Pier at St. Andrews, was originally made of timber, and later filled with stone rubble as a strengthening measure. This wooden pier, which had remained virtually intact since being built in about 1100, was almost destroyed completely in the 'Great Storm' of 1655. Thereafter, in 1656, another pier was built, although half the length of the previous one. At the time timber, slates and stone from the Castle ruins were sold to defray repairs, but in time stones from both the Castle and Cathedral were used to construct the first stone pier at St. Andrews (Moore, 1992). To begin with, the pier was built at a length of 270m, with a lighthouse at the end, to replace the decaying beacon on Lady Craig's Rocks, and remained there until 1849. The Long Pier, however, still required regular repair, even after it was built in stone, thanks to the many storms that periodically attack the St. Andrews coastline. Partly broken down in 1678, it needed repair in 1722, in 1788 half of the long pier collapsed after a storm and it was again breached by a storm in 1823. It had a concrete extension in 1898, with a further one in 1900 restoring it to its original length of 270m we see today

(Hay-Fleming, 1910 & 1957). Further strengthening occurred in 1947, and a comprehensive programme of repair and preservation has been ongoing throughout the late 1990's thanks to the St. Andrews Harbour Trust. This continual lengthening of the pier allowed for massively improved access to the harbour, bringing with it the lucrative steamer trade to St. Andrews.

During the 18th Century the idea of a 'Cross Pier' was broached (Figure 3.4). Built in 1722 it was initially designed to minimise sediment disturbance at the mouth of the harbour. However it was subjected to the same batterings as the long pier when in 1727 it was badly damaged by a storm. It was rebuilt, but again required rebuilding and slight extension in 1730, and yet more strengthening in 1770. Later, in 1900, a cemented groyne was added as extra protection in the hope of further holding back sediment, in an attempt to prevent the silting in the outer harbour basin (Moore, 1992).

And so, by the end of the 19th Century, the harbour consisted of the Long Pier, 270m, the Cross Pier, 70m, the Traverse Quay, 30m on the inner side, the Shore Quay, 170m, the Shorehead Quay, 90m and the smaller East Quay. The outer harbour was entered from St. Andrews Bay by a gap, about 15m wide, between the end of the Cross Pier, and the 'Burn Stools', and a point in the Long Pier (Figure 3.4).

As George Bruce, in his book 'Wrecks & Reminiscences of St. Andrews Bay' confirms

' ... there were both a long pier and a cross one then, although not nearly so long as the two double-piled wooden ones erected by Alexander I, about the year 1100. The first stone pier was built soon after what is called the reformation (in 1559), some of the stones being taken from those two handy above-ground quarries – those so-called Houses of God – the ruins of the once magnificent Cathedral, and the Archbishop's Manse (the old Castle), though some of our very minute historians say it was only the money from the sale of the ruins which brought about other stones to the pier – a matter of very little moment. The piers were built, enclosing part of the wooden one, but were destroyed by a storm and rebuilt about 1662 – partly from a sensible collection in the various kirks in the country, King Charles II, giving £162 for that purpose and towards the building of the 'Bow Bridge' – I presume the present Shore Bridge. They were not so long as the present piers of 1882, they were rickety too, like the state of St. Andrews at the time ... '

Not only does the layout remain the same today, with little alteration to both location and original materials, but the piers, quays and other features of St. Andrews Harbour are listed structures. To help maintain this historic site there is an ongoing and all-encompassing plan of regeneration work happening, under the aegis of the St. Andrews Harbour Trust.

3.2.5 The Royal George

The block of modern flats, distinctive to the panorama of today's harbour, were reconstructed from an old warehouse, an old tenement block that bore the name of the Royal George, and one of the two infamous Public Houses – the Auld Hoose. What was, the other public house, The Bell Rock Tavern still stands today, but is now a private dwelling.

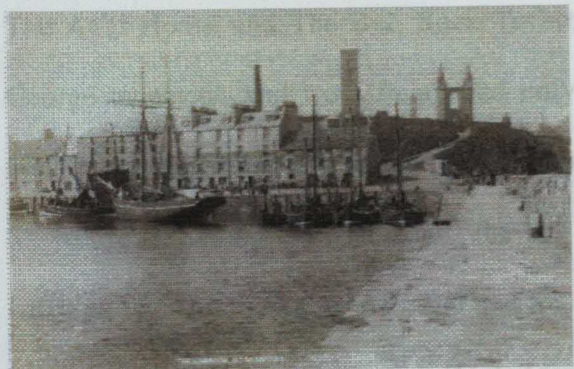


Plate 3.15: The Royal George Tenement with the Bell Rock Public House c. 1890

Plate 3.16: The Flats and the Preservation House c. 2002

The Royal George tenement, situated on the Shorehead Quay (Figure 3.4), with the harbour on one side and a Gasworks on the other, had originally been a series of warehouses. The building itself was named after a naval vessel, as were many other tenements in St. Andrews. It was converted to the tenement block in the 1850's with the majority becoming 'but-an-ben' accommodation for a large number of fisher folk. The remainder of the building was used as a granary and store. It also housed a shop at the front of the building and a public house at both ends – the Bell Rock Tavern and The Auld Hoose (Brown, 1984).

Likened by many to 'rabbit warren' living conditions in the Royal George were far from ideal. Often described as '*... an example of Victorianism at its appalling worst ...*' its picturesque harbour setting disguised the grinding poverty experienced by the tenants. Most fisher folk had large extended families, which resulted in up to eight or nine people living in two cramped rooms with outside lavatories housed inside the 'towers' of the buildings. There were no facilities for storing nets or fishing gear inside the houses, which mean that any available space was strewn with fishing gear, and the fumes from the gasworks coupled with the smell of the harbour must have made life extremely unpleasant.

The Auld Hoose and The Bell Rock Tavern were situated at either end of the Royal George tenement, and were frequented only by the local fishermen. The Auld Hoose remained a public house until the 1940's when it was then used as a meeting place for the St. Andrews Sailing Club, up until the late 1950's. The Club then purchased the old Lifeboat Shed on the East Bents, and that has been used as its meeting place ever since.

The building that housed the Bell Rock Tavern dates from 1750, having been built as a merchant's house with a granary store. The living quarters were converted into licensed premises in 1825, and the name is rumoured to have been inspired from Stevenson's lighthouse on the Bell Rock. Refurbished again to a private dwelling in 1938 it remains the oldest of the surviving harbour front buildings, and has been described as '*...one of the towns most distinctive 17th century houses ...*' (Hay-Fleming, 1957).

Bell Rock House was later gifted to the St. Andrews Preservation Trust, in 1938, by the then owner Mrs. Roberta Sekelska. The agreement allowed her life occupancy in the house with the Preservation Trust taking responsibility for the maintenance of the structure of the building. The Trust completely restored the house in 1980-1981 and further repairs were carried out in 1987. The building remains a private dwelling to this day.

The Royal George was also privately bought in 1867 by a local contractor and property developer of the time, George Bruce, in the hope that he could improve the living conditions of the families if the tenement. The building was fundamentally dilapidated, and there was very little that George Bruce could do.

It remained a site of much comment by the 'townspeople' of St. Andrews and the writer W T Linskill in 1922 claimed '*... the big block of houses along the harbour [that] was once granaries packed with grain, now is used for residential purposes, and is packed with people...*'. Government legislation designed to eradicate slum housing heralded the demolition of many of the old houses in St. Andrews. A demolition order was served on the Royal George in 1934, and was subsequently emptied of all its occupants by 1935. The former tenants were re-homed in the new 'municipal housing schemes' growing up on the outskirts of the Old Town. This contributed to the dispersal and subsequent decline of the fishing community in St Andrews.

The Royal George lay derelict until 1963, and was then demolished. The building was then converted into the flats that still remain today. The 'Shorehead' flats were designed by local architects of the time, Gillespie & Scott, and were built on this site in 1965 (Brown, 1984 & 1987).

3.2.6 The St. Andrews Gasworks Factory

The St. Andrews Gas Company, operational from 1835 to 1962, was situated immediately in front of the Cathedral's easterly wall and behind the Royal George tenement (Figure 3.4) (Plate 3.10). The first gasworks in Britain were built in the late 18th century and were generally private works installed to light individual buildings. The St. Andrews Gasworks was one of the first built to supply gas to more than just one building The idea of piping a supply of gas to different consumers via a central works came about with the setting up of the Chartered Gas Light & Coke Company in London in 1812, and by 1830 only the smallest towns and villages were without a central gas supply.

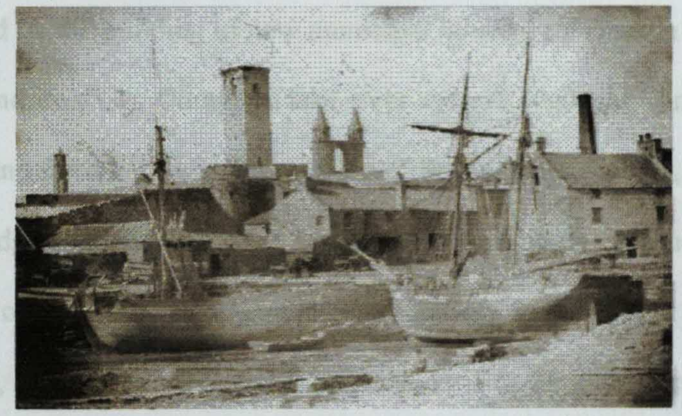


Plate 3.17: The St. Andrews Gasworks Factory: center of photograph

In 1834 St. Andrews Town Council agreed to provide £2500 for the setting up of the gasworks. The site purchased was described as *'... a piece of ground lying on the north west side of Pringle's coal shed at the harbour ...'*, and the manufacture of gas commenced in 1836. During the first two years of operation the factory had 300 consumers and 150 street lamps, but by the end of the 19th century most of St. Andrews was gas-lit (Lyle, 1997).

Initially the St. Andrews Gasworks made its own gas. Coals were delivered by boat to the harbour, each delivery roughly being equivalent to seven tones. This was transported from the harbour to the gasworks by carts hired from local coal merchants, Brown & Son.

During the later part of the 19th century however, with the introduction of the rail network, the coal was transported by train and brought to the gasworks by horses and carts supplied by Radleigh & Brown. From 1901, the coal was again was shipped in due to congestion at the railway station and from the 1920's motorised trucks replaced the horses and carts. In fact the last steamship ever to visit St. Andrews harbour for commercial purposes was the SS Locksley, which, in 1936, delivered 120 tones of coal for the gasworks. The factory building was greatly enlarged in 1918 to meet the growing demand caused by the building of new municipal housing schemes in the town, and 1936 saw the St. Andrews Gas Company take over several other gas companies in order to meet the demand for the growing population of St. Andrews (Brown, 1987). The cottage that now stands alone behind what was the Royal George, Kirkheugh Cottage, was originally part of the Royal George tenement building. It was bought by the St. Andrews Gas Company, in roughly 1875, who refurbished it to be their Foreman's house. The company was also granted permission by the Town Council to build a tunnel between the basement of that house and the gasworks so that coal could be taken directly into the works, to help with congestion at the harbour.

By 1951 ownership and management of the gas supply to the town had been transferred over to the Scottish Gas Board, rather than the private ownership of the Gas Company. Until 1974 the town was supplied with gas from Westfield Works, a local site, but owned by the Scottish Gas Board, whereby it was then connected to the North Sea gas supply.

From 1951 the gasworks lay derelict, until a demolition order was granted from the Town Council after demands were made to preserve the landscape of the harbour, and the building was razed to the ground by the end of 1960. What was a busy and productive Gas factory, nowadays, is nothing more than a strip of grass.

3.2.7 The Decline of St. Andrews Harbour

By the 1880's the ever-increasing size of the trading vessels landing at St. Andrews led to many problematic and potentially dangerous situations in the shallow, tidal harbour. The lack of general maintenance of the harbour itself, coupled with the competition from other east coast ports with greater natural advantages, led to a distinct decline in the use of St. Andrews Harbour. Even as early as 1816, a memorandum prepared by the Town Council refers to the harbour as 'ruinous'. Another in 1846, frequently mentions attempts to raise funds to '*... **deepen the harbour, to clear out the boulders and prevent the entry of sand...***' (Moore, 1992). Continually described as a 'disgrace to the town' it was evident that the harbour was no longer the bustling seaport of years ago (Ramshaw, 1993). The Town's inability to raise funds to repair and maintain the harbour meant that many ships refused to stop there, as the harbour was just too shallow.

Harbour records show that in 1846, at the height of the harbour's success, 155 trading vessels were registered upon arrival at St. Andrews. Hugh Brough-Fernie wrote in 1865 that the chief exports from the harbour were grain, potatoes and iron ore, while the chief imports were coal, timber, slate and salt. He also commented that the demands for exports were great, and that the harbour was a definite source of commercial gain for the town. However, many vessels were starting to bypass St. Andrews and sail up the Eden to Guardbridge to unload their cargo instead. The Ancient 'Seaport of Eden' was used as a mooring place prior to the Reformation, but now was seen as much safer place for the larger vessels to moor and unload. Sea trade at St. Andrews was also inevitably affected by improvements in roads and transport, particularly the coming of the railways in the mid-19th century. It meant that products could be dispersed around the country more quickly and safely than on cargo vessels. St. Andrews' first railway line, built in 1852, terminated on the Guardbridge road, the town didn't have a station until 1887. Again this was another factor in the decline of the business at the harbour, and why cargo vessels would sail straight up to Guardbridge (Bruce, 1884).

Although the number of trading vessels visiting the harbour was much reduced, the area still remained relatively important to the town as a place of commercial activity throughout the 19th century and early into the 20th century. W T Linskill writing in 1922, again commented that '*... **St. Andrews harbour is inviting and picturesque, but its former trade and bustle are a thing of the past ...***' (Hay-Fleming, 1957).

By 1922 there was a huge decline in the fishing trade out of the harbour, it no longer had a fleet, and the harbour wasn't used in any way by other vessels. By 1930's the fishing in St. Andrews had all but disappeared. Apart from a few fishing boats and a number of small private craft, the only vessels using the harbour tended to be rowing boats, which could be hired by the hour, and excursion boats offering trips round the bay.

Nowadays St. Andrews Harbour only supports a small fishing fleet, mostly creel fishermen seeking crab and lobster.

3.2.8 The Regeneration of St. Andrews Harbour

In 1897 the St. Andrews Harbour Trust, an independent, elected body, assumed official responsibility for the care and maintenance of the harbour and numerous attempts were made to raise money for necessary repairs. Despite these efforts, only minor improvements were made to the harbour during the earlier part of the 20th Century. The problem of finding money for maintenance and repairs has always dogged the Harbour

Trust, with public attention being largely limited to periods of obvious crisis. In 1958, for example, severe weather destroyed part of the long pier; this necessitated the launch of the 'Emergency Repair Fund' where public subscriptions of help were sought. With the further demolition of the harbour gasworks in the 1960's, the clutter of 19th century buildings that had obscured the Cathedral wall up to Kirkhill was removed. This, it was agreed, only served to emphasise the general air of neglect clinging to the area surrounding the harbour. The Harbour Trust, helped by the Preservation Trust, successfully managed to acquire a 'conservation area' status for the site and began to implement a programme of regeneration to improve the appearance and appeal of the harbour in an attempt to entice the lucrative tourist industry, the area was often overlooked by visitors to the town. This was further emphasised by Dr Robert Prescott, of the Scottish Institute of Maritime Studies, who described St. Andrews harbour as '... ***a fine example of a Scottish vernacular harbour*** ...'. In a report compiled for The Harbour Trust he emphasised the historical and archaeological importance of the harbour, it's considerably community and social value, as well as it's potential as a visitor attraction.

St. Andrews harbour is, therefore, currently undergoing a comprehensive programme of restoration and repair under the patronage of the Harbour Trust. This is part of a larger project concerned with the regeneration of the whole of the historic eastern area of the town. The Harbour Trust has developed a number of policies for conserving and managing the harbour area, taking into account risks to the historical integrity of the harbour including storm damage, heavy vehicle traffic and inappropriate or unsympathetic repairs or developments of adjacent properties. The main objective of the Harbour Trust and Conservation Plan is to '... ***adopt policies which will protect and***

maintain the historic structure of the harbour and its traditional uses, for the appreciation and enjoyment of the local community and the visiting public ...'

The harbour regeneration programme includes the restoration of much of the Long Pier and the Cross Pier, the renewal of the ironwork of the sluice gates and the replacing of the green sheds opposite the Traverse Quay, currently used by local fisherman, with a single stone building. There are also plans for a new café and harbour bridge. So far funding has been granted from the following bodies – £243, 000 from Historic Scotland, £350, 000 from the Heritage Lottery Fund, £50, 000 from Fife Environmental Trust and £17, 000 from community fundraising thought the 'Pier Project'.

In the course of 2003, the St. Andrews Harbour Trustees were principally concerned with advancing and completing the major repairs and restoration of Harbour structures. The primary contact works were complete and an opening ceremony carried out on 3rd March 2003 to commemorate, in particular, the pier being re-opened to the public.

More funding, in the form of £30,000 from Scottish Enterprise Fife and £25,000 from the Pilgrim Foundation were received in 2004. Other contributors include The Royal & Ancient Golf Club, St. Andrews University, Scottish Natural Heritage, The Hamada Trust, Fife Council, the Robertson Trust and St. Andrews Sailing Club, who have all donated undisclosed amounts (The St. Andrews Citizen).

It has generally been agreed of late that '***...at no time in its age old existence has the ancient harbour of the city looked more picturesque than in the past few years when it commercial use has practically ceased...***' (JK Robertson; in The St. Andrews Citizen).

3.3 The East Bents

The strip of land, that runs parallel to most of the inner and outer harbour, is known as the East Bents (Figure 3.4). Through out the entire history of the area it has perhaps been the site of the most development and changes, not only industry, but also new development and building work. The most prominent businesses inhabiting the East Bents included a sawmill, a foundry, stables, the town's laundry, a timber yard and a woollen's mill.

3.3.1 Gibson's Sawmill

Gibson's Sawmill was housed, in a specially built Mill, on the corner of Woodburn Place on the shore of the East Bents at the inner harbour, from roughly 1851 (Figure 3.4). The Mill owned three vessels, the *Henry*, the *Jane* and the *Ann*, which brought timber from the Scandanavia, specifically Norway and Sweden. This was a highly profitable sawmill, being the only one in this part of Fife at the time, so bringing a lot of traffic to the harbour area. Not only that, but the Gibson's also built a small dugout dock and boatyard and carried out many repairs to the fishing boats and other small vessels registered at St. Andrews. The sawmill was also instrumental in the diversion of the St. Nicholas Burn, so that it ran right past the Mill itself, ensuring a water supply to the sawmill. The site remained a sawmill until 1895 (St. Andrews Preservation Trust, 2003).

3.3.2 Spence & Gourlay Cleekmakers

The site of Gibson's Sawmill later became Spence & Gourlay, Cleekmakers, in 1895. The Mill was turned into a small foundry that made hand crafted iron club heads for the Golf industry. It was a hugely successful business, employing up to 25 men at any one time. It had to cease business with the outbreak of World War I due to the lack of a workforce, all of whom were serving in the armed forces, and the inability to source raw materials. The business was revived after the war had ceased, finally merging with another famous golf club maker, Robert Forgan & Son, in 1920. Briefly operating under the name of James Spence (St. Andrews) Ltd, it was relocated to Market Street in 1929.

3.3.3 Milne's Stables

During the 1920's, the Town Council then leased the old Spence and Gourlay property to various small businesses, including Milne's Stables. The site was well used by the townspeople, as the Stables served as a Riding School from the mid-1920's.

3.3.4 Woodburn Laundry

Woodburn Laundry situated opposite the site of the Riding School (Figure 3.4) employed two-dozen local women to service the local hotels, schools and houses. The Laundry worked in the town, and on that site, for more than 65 years, until it closed down in the 1950's. This building now houses the Estates and Buildings Department of the University of St. Andrews.

3.3.5 Balfour's Timber Yard

The Balfour family, owned a timber yard on the site that is now known as 'Balfour Place' (Figure 3.4). The land was later bought by George Bruce, who constructed houses rented to fisher families. The houses were restored and modernised in the 1950's, retaining most of the original facades, including the archways used by the timber yard to float the timber from the harbour to the yard.

3.3.6 Clatto's Mill

One of these houses in Balfour Place, thought to be No. 6 nowadays, housed Clatto's Woollen Mill and Shop prior to the refurbishment to private dwellings (Figure 3.4). The shop itself, called 'Stan Drew's' later moved to Church Square, before taken over by the Philip Brothers, who incorporated it into their world renowned St. Andrews Woollen Mill in the 1960's.

3.3.7 Other East Bents Developments

A putting course of 18 holes was formally opened on the East Bents on 25th June 1925 (Hay-Fleming, 1910). Unusually for St. Andrews, although still laid out to this day, it remains virtually unused.

St. Andrews University have also built a series of student flats, Albany Park, on land it acquired next to the Gatty Marine Laboratory, and Fife Council commissioned and built, the East Sands Leisure Center on land it acquired from St. Nicholas Farm in the late 1980's, early 1990's (Figure 3.4).

3.4 The University of St. Andrews' Gatty Marine Laboratory

The University of St. Andrews has been a major land developer in the East Bents area of St. Andrews. It owns large portions of land, and has been present here since the late 1800's. To begin with, the site of the Gatty, was a small unpretentious wooden structure. Hurriedly erected in 1882 in anticipation of of the need for a temporary fever hospital, a foreseen typhus epidemic failed to develop, and the building was converted for use as a pioneer Marine Station under the direction of the late Professor MacIntosh. It was completely destroyed by fire in 1896, but the research work that MacIntosh had been carrying out caught the eye of the eminent Charles Henry Gatty. Gatty secured funding and plans began for a new, purpose built lab to replace the old building, formally opened on the 30th October 1896 (Figure 3.4). It was designed by local architects Gillespie & Scott, was erected at the cost of over £3, 000 and was known as the Gatty Marine Laboratory from that day forward (St. Andrews Preservation Trust, 2003).

The current Gatty Marine Laboratory was extended in 2000-2001, providing state of the art facilities for training and research, as well as housing the Sea Mammal Research Unit, CREEM, the Marine Ecology Group, the Fish Muscle Group and many others. The Gatty Marine Lab is, nowadays, a world contender in Marine Biology research.

3.5 The St. Andrews Lifeboat Shed

With an active fishing and shipping industry regularly using St. Andrews Bay, there was an obvious and recurring need for the town to have its own lifeboat. As a consequence of the wrecking of the *Janet*, out of Macduff, Banffshire, St. Andrews' first lifeboat was acquired in 1801. First built in Scotland, similar vessels were retained in the burgh. The vessel was changed in 1823, and again in 1859, at which point the *Polly* was purchased. This vessel served until 1873 when the boat *The Ladies Own* was bought and saved lives until 1892, to be replaced by the *Lucy*, which lasted until 1910, and was followed by *The John and Mary Hatfield,* who had a long history of saving lives. It has been recorded that this boat saved 43 lives in her 28 years of service, and helped numerous vessels in distress. In 1914 she was called out six times and saved 16 lives, thirteen from the destroyer HMS *Success* alone. She even went to the aid of a seaplane that came down near to the West Sands in 1916 (St. Andrews Preservation Trust, 2003).

The waters of St. Andrews Bay were particularly treacherous, especially to sail powered vessels, and deaths by drowning were common.

According to Bruce (1884) St. Andrews Bay is '... ***the almost famously dangerous Bay ... the endless swell of whose dark blue bosom shall undulate lazily ... or, like a lion, lash itself into foam, and roll thundering to the beach ...*** '. He goes onto say '... ***there are a few bays more challenging than St. Andrews Bay ... on either side there is nothing but destruction and death staring the unfortunate seaman in the dance when once fairly caught within the jaws of this dangerous Bay in easterly storms ...*** '.

Entwined into the history of the Harbour area, as much as any other development, is the long record of the shipwrecks in the Bay. There are literally hundreds of wrecks on the floor of the Bay, and most of them are recorded within the history books of the town. Some of the more famous accounts belong to The Fantee 1875, The Merlin 1881, The Fransis 1891, The Prinses Wilhelmina 1912, and the Znamy Oktyabrya 1987. Section 3.3.8 provides a fairly large account of Shipwrecks in the Bay area (St. Andrews Preservation Trust, 2003).

The Lifeboat shed was housed at the East Bents, close to the current site of the headquarters of the St. Andrews Sailing Club (Figure 3.4).

The period of St. Andrews owing its own lifeboat ending in 1938, when because of the decline in fishing industry, it became difficult to recruit skilled fishermen to run it. Not only was there no lifeboat, but also for a period of many years, St. Andrews ceased even to have any sort of Coastguard station. This was rectified in the 1960's when a small office was built further along on the East Bents.

3.5.1 Shipwreck History of St. Andrews Bay

The St. Andrews Bay region has a long history of both a thriving shipping and fishing industry, which has endured an equally long shipwreck history. The stories of many shipwreck and rescues were reported in local newspapers through the eighteenth and nineteenth centuries, and serves to underlie the characteristics of the local waters.

From the 'Reminiscences of St. Andrews Bay', George Bruce

1765

ANNHILATION OF THE FISHING IN ST. ANDREWS

FIVE BOATS WRECKED AND TWELVE FISHERMEN DRWONED

Early in the morning of the 4th November 1765, the little fleet of fishing boats – then only five small yawls of about 25 feet keel – set their thin oak-barked lug sails, with a light breeze, for their fishing ground, then seldom beyond the Carr Rock, on the one jaw of the Bay and the Buoy of Tay on the other.

It frequently happens that the calmest weather, sudden and unexpected blasts from the north east agitate the sea long the coast, near St. Andrews, in so tremendous and terrible a manner as to cause imminent peril to the poor fishermen, before they are aware of their danger. Early in the morning when the fishing boats had set out, and went into deep waters' off the sand banks, the wind was hushed and the waves scarcely agitated, all was quiet and still.

About seven in the morning, however, a sudden and unexpected change took place; to the north east the clouds were observed to heave up and to scowl, and over cast the dawn. A storm was rapidly advancing. The fishermen instantly prepared to regain the beach. It was too late. The wind is up, sudden and powerful it bursts along in squalls, curling the waves, which foamed and broke furiously around the boats as they hastened to gain the nearest spot of safety, but in vain. Two of the boats, in their attempt to gain the beach, had got so close in, that friends of the crew had begun to wade in themselves to help.

On this awful occasion, three out of five boats were totally wrecked, and the other two so much damaged as to be rendered useless.

From the 'Reminiscences of St. Andrews Bay', George Bruce

5th January 1800

WRECK OF THE SLOOP '*JANET*', OF MACDUFF

There was no lifeboat when the 'Janet' was lost, in the dawn of 1800. to hear the dull boom of the breaker, and listen to the howling of the blast as it swept over St. Andrews Bay on the morning of the 5th January, when John Honey, without any ostentation, but with silent magnanimity, dashed amid the breakers, and, at the imminent risk of his own life, saved the lives of the master and four of the crew of the stranded 'Janet', lying maid the surf at the East Sands of St. Andrews, on a bitter, cold, sleety winter day. It was indeed a bitter cold day – the blinding sleet, driving before the biting blast, forced all who could, to stay indoors.

One glance sufficed to see, through the sleety blast, a vessel ashore amidst the surf at the East Sands, some 330 yards only from the safety of the East Bents. There, quite close, was the sloop – almost buried amidst the breakers, which dashed against and broke over her with irresistible fury, shrouded in surf and driving sleet, with the crew clinging on with the clutch of despair to the rigging of the wreck.

John Honey saved the master and four of the crew, while the sloop broke apart in the relentless breakers.

From the 'Reminiscences of St. Andrews Bay', George Bruce

1803

SHETLAND FISHERMEN BROUGHT TO ST. ANDREWS IN 1803

AFTER THE LOSS OF THE 'OLD FISHERMEN' IN 1765

After the loss of the five yawls in 1765, fishing in St. Andrews, was a trade, entirely ceased. There was no supply for the citizens. The wreck of the little fleet of boats, most with their crews, still known as the '11 Old Fishermen' gradually lost the power of deterring others to start again, as it were, at the very commencement of fishing in the City, but which made such a tardy and timid headway that, owing to some trifling dispute as to the inadequate supply of fish. Cathcart Demster, having a small estate in Shetland, proposed to the Town Council to bring two boats and crews from Brassey sound, and pay them 10 shillings a week, when they could not get to sea, and even pay them some money, besides the sale of the fish, when they went, providing they gave to citizens the fish chance of all the fish they caught.

Accordingly two Shetland yawls, with six of a crew each, came to St. Andrews from Brassey Sound in 1803. However only one of the boats remained for two months, before returning to Shetland, taking also half of the remaining boats crew, leaving behind only four of the crew.

These four men married into the city, and thus helped reform the nucleus of the fishing industry in St. Andrews.

From the 'Reminiscences of St. Andrews Bay', George Bruce

12th January 1823

WRECK OF THE TWO BRIGS IN 1823 – A YEAR MEMORABLE FOR THE LONG STORM

The 'Long Storm' commenced on the 12th January 1823 and continued almost without intermission until the 24th – slowly but surely enveloping the country beneath a white shroud of snow. After a week's cessation it again set in with renewed and increased severity on Saturday night, the 1st of February, and continued with great violence until Tuesday forenoon, the 4th, accompanied by a most severe NE gale. The roads were completely blocked up, the snow being drifted higher than the hedges and dykes – in some instances the wreathes being from fifteen to twenty feet deep. After this sudden renewal of the storm, the news from the sea was appalling. On Wednesday and Thursday there was a lull, and people began to think that the 'Long Storm' had done its worst: but on Friday morning it again burst forth with, if possible, redoubled fury, and the very heavy NE gale drove the dense flakes of snow before it. On Saturday the 8th the thermometer fell 20 degrees below the freezing point.

St. Andrews was in this position when news broke of the first of two brigs being in distress reached the citizens on the Saturday night.

It continued blowing and snowing, more or less, for nearly six weeks, embracing both land and sea and it's bitter, cold, icy grasp.

Through the blinding snowstorm a din light was seen glimmering from a large vessel in obvious distress, at this point she was abreast of the of the old Castle, driving fast before the storm, so fast that by the time help had made their way to the West Sands, the brig was ashore, stranded, like a helpless drunkard. Her crew of seven and a young boy, managed to wade to safety on the beach. The brig, '*Jean*' of Arundle, had been driven about in the storm for eight days. After the storm was over attempts were made to reflot the brig, but after all was ready, the sea rose and carried away her deck and top sides, leaving her bottom only. She became a total wreck. Her keel, keelson and florr timbers sank down, and imbedded in the sand, and for many years afterwards those black stumps could be seen at low tide.

The day after the Jean ran ashore, yet another brig was spotted, far out near the Eden Bar. This was the 'Itinerant' of London, also helplessly stranded, having been driven ashore before daybreak. Upon grazing the reef she was now stuck upon, the brig lost both her Captain and cook, washed overboard, never to be seen again.. after then being driven past the Carr, into St. Andrews Bay, the brig was seen lying ashore, about seven in the morning.

From the 'Reminiscences of St. Andrews Bay', George Bruce

9th May 1831

THE '*BETSY*', OF MEML. EMBAYED

A strong easterly gale – a heavy sea in the Bay – a group of men stood on the Kirkhill – a glass was levelled eastward, steadied against the corner of the dyke on the brae near the Flagstaff. 'Anything in the Bay, Gregory?' asked the Chief Boatman of the Coastguard. 'I think I see a hip through the misty haar, but a long way out, on this side of the buoy', was the reply. Through the 'misty May' storm, when it was partially cleared – like clouds from the moon, a large vessel was seen in the direction of the buoy of Tay. It was at that time of year when there is generally stormy weather, called the 'coo quack of May'. Without doubt there was seen a large brig, tampering with the storm, in too close proximity to the banks of the Tay, within the jaws of the storm, but, like a mouth round the light, gradually nearing the circle of death.

On the third day, after noon, it cleared and the brig was seen to head north west, and square her yards in the direction of the Eden. Suddenly she stopped, as if struck by a torpedo, wore, braced her yards, shuck out some reefs, set more sail and stood south – the wind of SE. Her conduct inexplicable then, was known afterwards. Bound for Dundee the Captain, uncertain in the misty storm, overran his distance, on clearing, mistook the sheet of smooth water in the Eden for the Tay, as there were more then a dozen vessels riding there at the time, until the breakers and his lead warned him, but hardly in time. He seemed all at once to find out his mistake, crowded sail on her until she staggered in the gale, and, as the large brig came plunging through the broken water, under a press of canvas, many a heart beat quick. A heavier sea than usual struck her and almost buried her within the white grasp of the

breaker, clearing the Lady Craig and heading south.
After two days labouring in the heavy seas, the brig was finally boarded by a local Boarhills man, and the St. Andrews lifeboat crew, who managed to sail the *Betsy* to the Tay, at a charge of £7 a man.

From the 'Reminiscences of St. Andrews Bay', George Bruce

November 1831

WRECK OF A DUTCH GALLIOT

The next service the St. Andrews lifeboat did do, was rescue the crew of a Dutch galliot, laden with herrings, From Fraserburgh to Hamburg – five men.
She has been buffeted about several days, and driven ashore at the West Sands, near Eden Bar. She was stranded before daybreak, at low water, the worst time to strike.
When first seen, through the haze of a cold drizzling, winter morning, she was rolling in the midst of a heavy surf and a strong easterly gale. It was plain that if the storm increased she would become a total wreck, with most likely the loss of her crew, sand it was feared that that the rising tide would break her up before she was reached, so no time was to be lost.
The lifeboat was promptly drawn down, wheeled out to the sands, and launched. When they drew alongside, which they did with difficulty, owing to the heavy surf – the mate was trying, with board and log line, to see which way the current ran, before trying to save themselves in their own small boat. Not ten minutes after the lifeboat got clear, and was driven ashore with the crews near the feet of half the citizens of St. Andrews, her deck burst up, and her masts feel over her side a complete wreck, which drove up as the tide made.

From the 'Reminiscences of St. Andrews Bay', George Bruce

November 1839

THE WRECK OF THE *'PETREL'* OF STOCKTON-ON-TEES

In November 1839, and easterly gale, with a heavy storm of sea and blinding snow, swept into the Bay. The first sign of a wreck at St Andrews was seen by two pilots going along the East Sands looking for their partan creels. They followed up a storm strewn trail of belongings until they cam upon the wreck of the *'Petrel'* lying near high water mark – a shattered ruin, with remnant of spars and logs strewn all over. This was one of the saddest wrecks that ever occurred in St. Andrews Bay, as it happened at night, in the middle of a blinding snowstorm, a fearful gale, and very heavy sea, unseen by man. All hand were lost but the second mate, who crawled ashore and lay on the lee side of a dyke, in a filed of turnip, the hwole of that bitter night. She had a crew of nine and a lady passenger on board. She struck about midnight, near low water, with as much sail as she could carry. Her Captain, thinking he was in the Forth, took no soundings in the fearful storm. No lights could be seen through the thick, blinding blast of snow – neither the Bell Rock nor the leading lights of the Isle of May – while the piercing gale and dreadful sea were amongst the heaviest ever known in St. Andrews Bay.

From the 'Reminiscences of St. Andrews Bay', George Bruce

10th November 1848

TWO YOUNG FISHERMEN DROWNED

On the 10TH November 1848, the day before the Martinmas term, the fishing boats went to sea bout three am, ebb tide, to wait for daylight. It was a lovely morning, the moon – Nature's thrifty candle and her tidal queen, ever waning, yet never consumed – was burning in the heavens, with only a small piece off the top, so that boats, could easily be seen in the Bay close by.
It was said that two young lads had been sky-larking about in one of the boats, fallen overboard and drowned. Such is the treachery of the sea in the Bay that neither body were even found.

From the 'Reminiscences of St. Andrews Bay', George Bruce

March 1854

A LARGE RIG EMBAYED AND LOST

In the grey dawn of a March morning in 1854, in a heavy ESE gale and heavy sea, a brig was seen – under double-reefed topsail, courses, reefed trysail, and jib – steering for the banks of the Tay, evidently out of her reckoning. St.Andrews being often mistaken for Dunbar, vessels run up the Bay instead of the Forth – into a trap instead of safety. She was almost on the banks, unaware of danger, till the breakers warned him; and just in time for she was near ashore. She wore, and tried to work out, but that worst of gales for our bay, and ESE, right in his teeth, she made nothing of it. She again wore, and tried the other tack, but she was too far into the fatal trap to get out in such a heavy sae and gale. After struggling the whole day in vain, she cast her lasr die on her nachors, but too far north, too near the deadly banks of Tay. The brig was eventually lost, with all hands.

From the 'Reminiscences of St. Andrews Bay', George Bruce

3rd October 1860

HEAVY NORTH WEST GALE – FIVE BUCKHAVEN TRAWLERS IN PERIL

When trawling in the Bay five Buckhaven boats were caught in a very heavy NW gale – in fact, a hurricane – in 3rd October 1860. the water was lifting, the spindrift flying like smoke, unable to carry sail, some of them split, they let go their anchors between the pierhead and Kinkell Ness, one of them was parted from her anchor, and was drifting on the south rocks; as a last resort they threw over their trawl to act as a drag, but she was fast approaching her doom. Luckily the steamer '*Scottish Maid*' steamed up close and caught her just in time to save them.

From the 'Reminiscences of St. Andrews Bay', George Bruce

7th January 1861

SUDDEN STORM

On Saturday, the 7th January 1861, one of those sudden SE storms so prevalent on the east coast of Scotland caught the whole of our fishing fleet, past noon, when about forty miles east from Bell Rock, and by the time they could have reached the harbour it would have been dangerous to risk an entrance, as the tide would have been back. One of the fleet was driven onto the 'Burn Stools' and nearly stove to pieces; the crew was saved. By this time the tide was flowing, but blowing a gale, a heavy sea, and very dark. Finally the rest of the fleet were hurled to relative safety in the harbour, thanks to the guiding lights of the towns people on the pier.

From the 'Reminiscences of St. Andrews Bay', George Bruce

18th February 1861

L

OSS OF A JERSEY SMACK AND ALL HANDS

Past midnight on Monday, the 18th of February 1861, another sudden SSE gale swept the bay. At dawn two sloops or smacks were seen fighting with it. One of them – the 'Mary' of Crail, laden – risked and ran into the harbour, without a pilot, the other seen labouring heavily off the pierhead. At first it was thought she, too, bound for St. Andrews, but, like the grey mist of the morning, this was dispelled as the day advanced for, the storm increasing, she was still plunging in the bay, trying to get out; her jib was split, her mainsail split. The smack went down that night, with loss of all hands abroad.

The Fifeshire Journal

Thursday October 27th 1864

FEARFUL SHIPWRECK NEAR ST. ANDREWS

We have to record, as one of the incidents of the storm which raged with such violence from Friday to Sunday night last a most distressing and appalling shipwreck on the rocky beach, which hems St. Andrews Bay to the eastward.

THE WRECK

On the Sabbath morning the gale had reached its climax, and the whole of the bay and coastline eastwards from St. Andrews. The wind blew from east by north. Dashing the sea directly against the shore, about twelve o'clock a pretty large brig was observed making across the bay from the northward, and her dangerous progress soon attracted the attention of crowds of observers.

When first seen she was apparently about five miles out of St. Andrews, and soon drifted before the gale considerably nearer, so that from her course there appeared very little chance of her avoiding the coast either at the eastern extremity of the Bay or at Fife Ness.

Thinking that she might be standing in for the harbour, and would thus be likely to run against the rocks to the east of the town, or else upon the sands, the large new lifeboat was hastily got ready for any emergency.

The wreck occurred about twenty minutes passed one. It was then dead low water, and the vessel stranded upon a ridge of rocks for or five hundred yards from the high water mark. After striking, she lay firm and easy upon the ledge of the rocks, and continued to do so until the flow of the tide.

AFTER THE WRECK

The scene of the melancholy disaster was visited by crowds of people on Monday and Tuesday. The hull of the brig had been thrown bottom upwards, upon the plateau of rocks, and was uncovered at low tide. The name board of the brig – *Napoleon, Fran Udedvallia* – was washed ashore on Monday.

The entire crew of five seamen, and one boy, were lost in the storm.

The Fifeshire Journal

Thursday December 1st 1864

THE RECENT SEVERE STORMS
THE WRECK OF THE DALHOUSIE
LOSS OF THIRTY THREE LIVES

The stranding of the Dundee and Newcastle steamer Dalhousie on the Abertay Sands on Thursday night last is one of the saddest and most terrible events that ever occurred in the Bay of St. Andrews, or perhaps anywhere on the eastern coast of Scotland. That all on board the vessel perished, either with the ill fated vessel or in vain attempts to get in land, is now past doubt, and sad and terrible as the calamity was at first believed to be, father information, which reached Dundee from the sailing port on Saturday afternoon, first showed its full extent, and made known the extent of loss of life which attended it.

The Dalhousie sailed from Newcastle on Wednesday morning at ten o'clock with a crew of twelve mean, including the captain and a boy. Besides her crew the Dalhousie took on board at Newcastle eleven passengers.

Captain Rattray, captain of the steamer *London*, conveyed to the Dundee Harbour Master that a large vessel was in distress in St. Andrews Bay. While he'd struggled against heavy sea's to land his own ship he, himself has witnessed a rocket fired from a vessel apparently in distress near to the Abertay Sands. The night was pitchy dark, squally, and dirty, with a heavy sea running.

Shortly after midday the next day the dreadful news reached Dundee that the ship had gone down with all on board.

The Fifeshire Journal

Thursday January 5th 1865

VESSEL PICKED UP AT SEA
A RATHER MELANCHOLY TERMINATION

The schooner Andrew Wilson of Inverkeithing – laden with pit props for Newcastle – with a crew of five, struck the Carr Rock on Monday night or early on Tuesday morning. With the flood tide she floated off, and although making water fast they continued to work her up the Bay to nearly Boarhills, where they cast anchor, and left her in their own boat.

The sea was calm as a loch, the wind light and about south-west. The boat made for St. Andrews, which they reached in safety, and obtained a crew of fishermen to go off with them to their vessel.

Later that day they were caught either by a gust of wind or strong current, and the vessel went down bow first, but came up again, and then heeled over on her broadside. One man's live was lost.

The Dundee Advertiser

Friday 6th January 1865

LOSS OF SCHOONER AT THE MOUTH OF THE RIVER TAY
A FISHERMAN DROWNED

On Wednesday morning at one o'clock, a schooner was lost at the mouth of the Tay, and a poor fisherman, one of a party who were on board for the purpose of rendering assistance, was unfortunately drowned. The particulars in connection with the loss of the vessel are as follows – On Tuesday afternoon about two o'clock a pilot from St. Andrews came to Dundee by train, and called at the office of Mr john D Easson, Dock Street, who has the management of the steam-tug *Hercules*. The pilot stated that there was a schooner in distress and water logged in St. Andrews Bay, and that he had come to Dundee for the purpose of getting a tug to tow her into the harbour. About six o'clock in the evening the schooner was seen in St. Andrews Bay. The Captain stated that on about nine o'clock on Monday night the vessel had hit the Carr Rock, thanks largely due to the gale blowing at the time. The crew being apprehensive of the danger that awaited them

were they to continue on board the schooner after weighing anchor, put off to St. Andrews in their boat with the view of obtaining help, and succeeded in reaching a creek near Boarhills – a short distance form where the *Napoleon* was lost – about four o'clock in the morning.
About half past eleven o'clock the schooner was taken into tow, and the tug proceeded to Dundee. A breeze had sprung up from the SW, but shortly after 12 o'clock the wind very suddenly increased into a strong gale accompanied by a heavy swell. By one o'clock in the morning, and without warning, the schooner suddenly capsized and lay broadside in the water, and in an instant was submerged.
The scene was one of great excitement and one of the fishermen stated that that he never remembered to have witnessed such a fearful accident. He was able, with two other men, to save the lives of three men. The cries of a forth were clearly heard in the water, but the darkness of the night prevented any assistance being rendered to him. The tug sailed round and round the wreck in order to make certain that no poor fellow was floating around in the surf, sand after careful examination no one was seen, and the weather was becoming worse and worse every minute.

The Dundee Advertiser

Friday 6th January 1865

ST. ANDREWS IN TROUBLE AGAIN

Somehow St. Andrews seems determined to get a bad name for itself, another loss of human life has taken place in the bay, or a little beyond it, through what our correspondent very justly terms 'sheer mismanagement'.
It seems that the schooner *Andrew Wilson* of Inverkeithing struck on the Carr Rock on Monday night and got waterlogged. Ultimately she was abandoned, near Boarhills, and the crew came to St. Andrews next morning, for assistance; but meanwhile a number of fishermen had observed the schooner in distress, and making up to her had boarded her, and were bringing her back to St. Andrews, just as her own crew were going out for her. A dispute then arose about 'salvage', with both partied refusing to quit possession until suitable remuneration had been made. An agreement was therefore made to take the schooner to St. Andrews for repair. After finding no refuge for the sinking barge at St. Andrews, decision was made to sail her to Dundee. But as was to be expected, and as those skilled in marine affairs correctly predicted, she had not proceeded far across the bay when she sank – her crew, five in number, all going down with her, with one, David Gourley, never to, rise again.

From the 'Reminiscences of St. Andrews Bay', George Bruce

April 1865

FISHING YAWL CAPSIZED – 'BILLY THE BOY' – DROWNED

As the 'Fox' was capsized and crew drowned on the April Market-day of 1858, so was this St. Andrews yawl sunk and crew drowned, on the April Market-day 1865, when returning from fishing, with two ring, in her foresail and sheet fast. A sudden squall struck her, the wind westerly and flanny, when about a mile north east from the pierhead. She filled and sank all the quicker from their creels, being, filled with a good shot of fish. Three fishermen lost their lives, including William Thomson, better known as Billy The Boy

The Fifeshire Journal

Thursday April 13th 1865

FISHING BOAT SUNK

LOSS OF THREE LIVES

On Monday forenoon a sad accident occurred, which has cast quite a gloom over the city. A small fishing yawl on returning from the mornings fishing was caught by a qualm of wind from the shore and went down at once. The early part of the day was gusty, although mild, and the sea perfectly calm. Although as usual, many interested had seen the yawl coming, there was absolutely nothing to interest anyone especially to her safety, so that no one noticed the sad disaster, or can describe how it occurred, and yet it was observed within a few minutes, for the boat was missed.
A boat was immediately manned and pulled out to the spot with all energy. The boat contained a crew of three, and the Captain was found, evidently dead, but all efforts were made at the Coastguards. No others could be seen.

The Fifeshire Journal

Thursday October 21st 1875

WRECK IN THE TAY – GALLANT CONDUCT OF THE ST. ANDREWS LIFEBOAT CREW

The waters in St. Andrews Bay have been very tumultuous ever since Thursday 14th October, and on Monday it blew very hard from the SE, accompanied by a somewhat thick haze. The coast outline was difficult to catch sight off. In the course of an afternoon a vessel was observed running into danger. Had she continued on her course she would have landed on Kinshaldy sands, but cannons were fired at the battery and she out about for the north, not, however to reach safer quarters, as eventually she was stranded on the bank of the Tay.

By skilful management the crew of the lifeboat, after launch from St. Andrews, succeeded in reaching the struggling vessel. The sea here was something tremendous, and the boat was sometime entirely submerged. She, however, behaved admirably, and came to the surface like a duck.

Further efforts on the part of the St. Andrews boat thus being rendered unnecessary she turned homeward, and was safely beached shortly after six o'clock on the West Sands.

The Fifeshire Journal

Thursday 28th October 1875

VESSEL ASHORE – CREW SAVED – BY THE LIFE BRIGADE – EXCITING SCENE

The long-continued gale from the east raged severely on Wednesday, and a watch was maintained all day in case any craft should get embayed. During the forenoon one or two made the Tay successfully, but during the afternoon, just about 4 o'clock, a large vessel, the '*Fantee*' was discovered on the horizon endeavouring to clear the Carr Rock. It was seen that the attempt would prove futile, she being too far in, but was hoped she'd make the Tay. After tacking away to the north for some time during which she had some heavy seas, she squared her sailed and bore right down for St. Andrews. It then became apparent that the captain had lost his reckoning, and the lifeboat was got out and held in readiness. About 6 o'clock, and just when darkness fell, the vessel had reached a position two miles east from the harbour. She was then hove to, and lights were burned, which denoted that help was wanted. The lifeboat was then manned by a capital crew of young fishermen, and she was pulled to the beach. An unfortunate occurrence here took place. The boat had no sooner left the carriage then the surf, which was breaking very heavily on the shore caught the boat and carried her to land, the receding wave leaving her high and dry.

Through the 'mirk' the ship was seen driving in as fast a wind and sea she could bear. Going north of the pier, she first struck bottom on the Lady Craig Rocks due north of the pier. She then went broadside on to the waves for some hundreds of yards. At this time an anchor was let down, and the vessel swung round and went in stern first between a ledge of rocks, until she reached a position behind, and within a hundred yards of, the Castle.

From the 'Reminiscences of St. Andrews Bay', George Bruce

3rd December 1876

THE FOREIGN BRIG 'SVANTE' OVER EDEN BAR

The brig, from the Tyne for Wisby, Sweden, encountered a very heavy ESE gale. When fist seen in the afternoon she was running up the bay pretty far north, heavy breakers all around her – with only her topsail set, the rest of her sails in shreds. When near ashore at the mouth of the Eden the mate ran up the rigging. He saw a large sheet of dark smooth water, like a lake, right ahead. The Captain steered for it – luckily it was high water, and the height of a spring tide. When the breakers were surging round him 'like hell', as if he's known the Eden bar all his life, steered right over it, bumping it once or twice, knocked away his false keel, and, leaving the storm behind him.

From the 'Reminiscences of St. Andrews Bay', George Bruce

A GLANCE AT SEVERAL WRECKS NEAR FIFNESS BETWEEN 1876 AND 1881

On August 30th 1876, the smack the '*Gypsy Queen*', capsized and became a total wreck on Fifeness.

On the 14th August 1877 the schooner '*Eugene*' was also wrecked at Sanderson.

On 19th September the S.S. '*Anna*' also at Randerson.

The S.S. '*Fairy Queen*' was wrecked on Balcolmy Brigs, on the 29th December 1877.
On March 20th 1879 the schooner '*Rap*' was wrecked at Randerson again.
As was the '*Juno*' on the 9th April, three of the crew drowned.
On the 14th July the brig '*Annette*' was also wrecked at Fifeness.
As was the brig '*Andreas*', on the 16th December of the same year, 1879.
On the 16th February 1880 the S.S. '*Mabel*' was partially wrecked at Boarhills.
The schooner '*Speculation*' was lost at the mouth of the Eden on the 9th November 1880.
On the 21st December the schooner '*Grace Rome*' was wrecked at Wormiston, near the Carr Brigs.
As was the S.S. '*Stornoway*' and another, S.S. 'Spey, on the same tide on the 21st December of that year.
On the 24th January 1881 the S.S. '*Gloamin*' was wrecked near Boarhills.
On the 5th March 1881 the schooner 'Harmonie' and the barque '*Merlin*' were both wrecked the same day, one on the West Sands, the other bear the old Castle.

From the 'Reminiscences of St. Andrews Bay', George Bruce

23rd and 25th October 1881

STORM AND SHIPWRECKS

The ESE storm which began on the 19th, continued with increasing fury until Sabbath, when it culminated in a perfect hurricane. In the morning the news came from Crail that a Norwegian brig, the '*Lovide*' had been wrecked there, and 4 of her 6 crew drowned. Just as the kirks bells were ringing for the forenoon's service the boom of the cannons sounded that there was a ship in the Bay. The schooner was seen running before the gale in the direction of the Eden. Contrary to belief she managed to outrun the wind and entered the port of Eden in relative safety.

The St. Andrews Citizen

Saturday April 11th 1891

ANOTHER SHIPWRECK AT ST. ANDREWS

LIFEBOAT CREW IN DANGER

Those who were still beneath the blankets between eight and nine o'clock on Sunday morning were somewhat rudely awakened from their slumbers by the firing of signal rockets, indicating that a ship was in a dangerous position in the Bay. Crowds soon began to gather at the Lifeboat House, the Castle and other places whence a view of the Bay could be commanded, and from which a brigantine was to be observed a few miles distance from the shore with scarcely a stitch of canvas, and in considerable danger of being driven ashore. After having drifted to the south-east, she anchored nearly opposite the Kinkell Ness, and in perilous proximity, to the jagged rocks at that portion of the coast. The St. Andrews lifeboat crew were at the house immediately after the signals, whence the boat was brought from her house, and put in sea-going order, and speedily launched from the beach. The lifeboat crew were unceasing in their endeavours to pull the boat through the surf, but the contrary wind and the force of the breakers rendered their labours to no avail. The crew were finally signalled to return – their being no hope of her rendering any service to the distressed vessel.
During the crew of the distressed vessel being brought ashore by the lifeboat at Boarhills, three of them were washed overboard, but were kept afloat by their cork jackets and rescued. Shortly after the crew were landed, the *Francis* parted form her anchors and was driven on shore.

The St. Andrews Citizen

Sunday 17th May 1902

SAD FISHING BOAT DISASTER AT ST. ANDREWS

YAWL UPSET, AND TWO MEN AND THREE BOYS DROWNED

On Monday evening a most distressing disaster occurred to a fishing boat containing a crew of five, and one of the darkest pages in the history of local fishing industry falls to be written. About five o'clock on the above evening a yawl and her crew went out to shoot nets in the Bay. There was a strong north-east wind blowing, and a nasty sea was in consequence running in the Bay. When the doomed boat was about two miles out, directly north from the Cathedral ruins, it is supposed that a sudden squall had upset it. The boat being water logged and ballasted, it would at once go under water, and the fate of the unfortunate men can well be imagined. No one witnessed the accident. Several fishermen on the shore, who were aware that the boat was out in the Bay, missed sight of her, and it was at once surmised that something had gone wrong. No trace of the crew could be found by a search party of five other yawls, but there was no doubt as to what their fate had been.

The St. Andrews Citizen

Sunday 17th May 1902

THE WRECK OF THE PRINSES WILHELMINA

On 29th September 1912 a fierce storm broke out in St. Andrews Bay, and raged for several days, increasing in severity as each day passed. By the 1st October is was known that a boat in the Bay was in trouble, the alarm was raised and the lifeboat was launched. The Prinses Wilhelmina was initially grounded on the rocks at the Castle, where nine of her crew were rescued. The boat was then pulled back out to sea with the tide, finally coming to rest on the West Sands.

3.6 Coastal Protection Measures

Coastal erosion has always been a problem in St. Andrews. For at least the last hundred years or so successive Town Councils have conducted a 'make-do-and-mend' policy. So many parts of the St. Andrews coastline require attention each year, the East Sands, the West Sands, the Golf Courses, the Castle buttresses, but money was just never available and previous Councils refused to see it as a problem.

The East Sands, as mentioned in Chapter 2, is heavily armoured against the onslaught of the waves from the Bay area. The entire back of the beach terminates in three sections of seawall, planned, designed and built to protect the land developments from the regular inundation from storm surges.

The north section was the first to be constructed, as early as 1877, to go some way in helping to prevent the regular breakthrough of the Kinnessburn over the East Bents in storm events (Estates & Buildings Historic Map, Figure 3.4).

The next section to be built was the south section, which is constructed from concrete and masonry, and was commissioned by the landowners that used to own the St. Nicholas farming land that is now the site of the East Sands leisure Centre. Constructed in the late 1940's early 1950's, it remains wholly intact since its assembly (St. Andrews Preservation Trust, 2003).

Reorganiasation of Local Government within Fife resulted in conmfisuion of responsibility for coastal protection and coincided with the loss of many related records, particularly those relating to the central sea wall installation at the East sands. This section, of sheet piling, was commissioned by the former North East Fife District Council, and was built in the early 1960's.

The University of St. Andrews Estates and Buildings can confirm that at the time of writing this piece of work, it is not possible to determine which body has responsibility for, and authority over the maintenance of the coastal defences on the East Sands. It would seem logical that Fife Council owns them, yet they claim to know nothing of them, and could not provide any information pertaining to them.

Chapter 4

Beach Processes

With beaches fringing about 40% of the world's coastline and a third of the world populations living on them (Bird, 2000), it is imperative to understand the dynamics of these systems through the processes influencing their evolution, in order to effectively manage and develop any shoreline for the future.

Coastal environments are fundamentally shaped by tides, waves and currents, which together provide the energy that changes, develops and modifies it. The roles of tides and tidal currents are subtle, as the driving force behind almost every coastal process is largely wave activity. However as the sea level rises and falls, the size and shape of the shoreline affected moves, continuously changing the portion of beach influenced by the waves; and so, the greater the tidal range, the wider the band of change.

The term 'coastline' can be defined as the interface between the marine and the terrestrial environment, although coastal environments can clearly extend both above and below this definition.

The changes that occur on beaches can take place in intervals as short as the time between individual waves striking the shore, or as subtle long term changes taking place over several decades, hundreds of years or millennia etc. Events also have the potential to be instantaneously near catastrophic or much more gradual, thus making the degree of change slight or dramatic, but always continual. In theory, a level of predictability about this change is only possible because these changes tend to cyclically respond to seasonality.

All reference to forms, processes and distributions within any coastal environment are related to 'sea level' as a measuring datum, therefore we need to define this parameter.

Conventionally by using the term 'sea level' we are referring to the level of the ocean's surface, especially the level halfway between mean high and low tide. This is used as a standard in reckoning land elevations or sea depths. In the UK we specifically refer to sea level as the elevation above Ordnance Datum – which is the height of mean sea level originally determined at Newlyn, in Cornwall, during the period of 1917-1926. Mean sea level can be determined for all locations in the world, which then defines an important reference surface from which we can measure all heights and depths.

Sea level is repeatedly affected by the following potential parameters; tectonic changes – subsidence/emergence, operating over millions of years, glacial isostacy and glacial eustatic movements – operating over thousands of years, thermal changes – annual variations off the coast of Scotland, air pressure changes – daily and weekly variations, wind action – short term duration, tidal variations – diurnal variations and extreme events such as storm surges and tsunamis – which are periodic variations.

To gain an insight of how these processes shape beaches we must look at each phenomenon separately in order to build a detailed picture of a coastal system, and pinpoint the processes at work on the East Sands.

For the purposes of analysis, the relevant sections of 'the shoreline' are classified as in Figure 4.1.

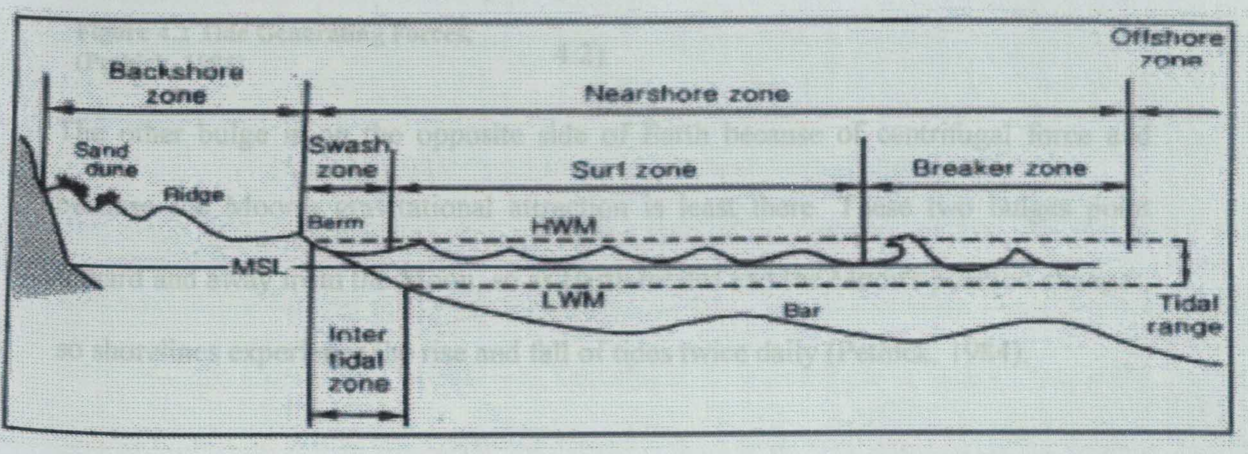


Figure 4.1: The Coastal Zone and its Component Morphology, Tide and Wave Environments, (Viles & Spencer, 1995)

4.1 Tides

Tides are the twice daily rise and fall of sea level and result from the gravitational attraction of the Moon and the Sun on the free moving waters upon the Earth's surface, and although the Sun is more massive than the Moon, it's impact upon the Earth's tides is 46% less than that of the Moons because the square of the distance of the latter from the Earth is much greater then that of the sun (Pethick, 1984). Tidal theory stems from Newton's gravitational theory subsequently modified to take into account the dynamic nature of water movement.

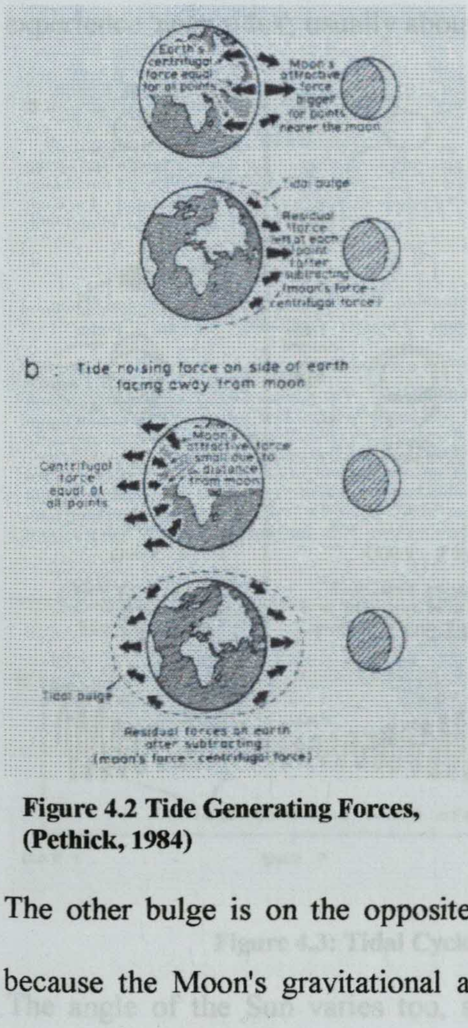


Figure 4.2 Tide Generating Forces, (Pethick, 1984)

Tidal activity is the most important factor in determining all sea level variation; as any periodic changes in sea level are responsible for altering the point of impact of wave activity on the coast and, in doing so, help to define the nature and form of the intertidal zone.

The tide generating forces of the Moon produce two bulges on the oceans surfaces (Summerfield, 1991), one bulge extends towards the moon as it is on the side of the Earth where the Moon's gravitational attraction is the greatest (Figure 4.2).

The other bulge is on the opposite side of Earth because of centrifugal force and because the Moon's gravitational attraction is least there. These two bulges point toward and away from the Moon, so as Earth rotates and the Moon's position changes, so shorelines experience the rise and fall of tides twice daily (Pethick, 1984).

The Moon revolves around the Earth every 28 days, changing its position with respect to latitude. Meaning it takes the Moon fifty minutes longer to return to the same position each day, hence the reason that the 'tide times' change on a daily basis.

Tides are further complicated by the combined effects of both the Sun and Moon. When the sun and moon are aligned every two weeks, their forces together generate 'spring tides', usually about 20% higher than normal. But also when the Sun and Moon are at right angles to each other, also at two-week intervals, the Sun's tide generating forces cancels out the some of the Moon's force, so the shoreline's experience 'neap tides', usually about 20% lower than normal (Figure 4.3).

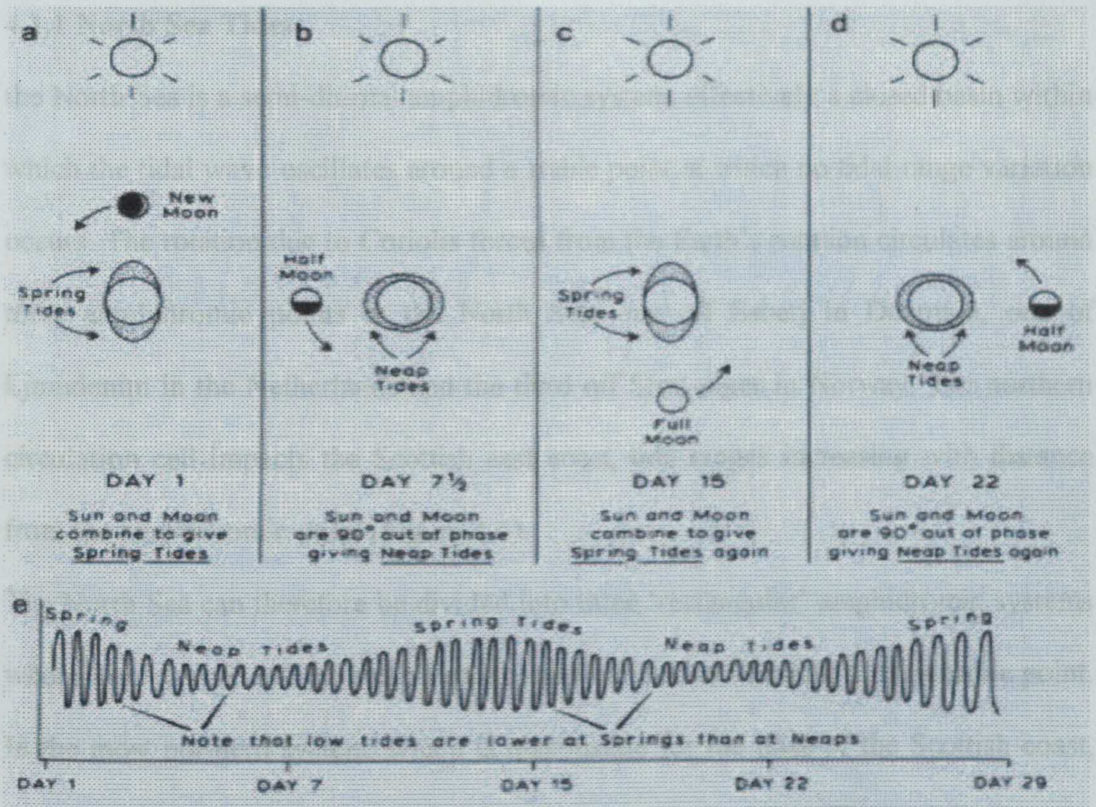


Figure 4.3: Tidal Cycles During the Lunar Month, (Pethick, 1984)

The angle of the Sun varies too, so at the time of an equinox - when the Sun is overhead at the equator and aligned with the Moon – and will produce higher spring tides, usually around 21st March and September. Conversely at solstices - when the Sun is high, and not in line with the Moon - shorelines will experience the lowest spring tides, usually around 21st of June and December. The Earth also moves closer to the Sun during the 'winter' months, so these tides, in the northern hemisphere tend to be higher than 'summer' tides, and the autumn equinoctial tides can be expected to be the highest of the whole year (Pethick, 1984).

Thus changes in the sea level caused by these lunar tides provide a controlling mechanism allowing short term cyclical changes. Tides themselves, then, can be said to play a passive role in actual sediment transport and direct changes in morphology of beaches, but first and foremost they expose and cover large portions of the beach and inner surf zone.

4.1.1 North Sea Tides

the North Sea is a semi-diurnal amphidromic system, effectively a closed basin within which the tidal wave oscillates around a stable point at which no tidal range variation occurs. The rotation due to Coriolis forces from the Earth's rotation circulates around three amphidromic points in the North Sea; one off Esberj in Denmark, one of Ljmudenim in the Netherlands and the third off Stravanger in Norway. The northern circulation cell impacts the Scottish east coast, tide ranges increasing with distance from the amphidromic point (Figure 4.4).

The North Sea can therefore be divided into three 'rectangular' amphidromic systems where the tidal wave (high water) rotates anti-clockwise round an amphidromic point. In the most northern system, which is responsible for the tides of the Scottish coast, the amphidromic point of no tide is just off the Norwegian coast (Figure 4,4).

Tides, therefore, essentially have a great impact on shorelines because they are the reason the area of wave attack constantly shifts on and offshore, i.e. as the tides rise and fall (Pethick, 1984). Thus, any tidal extremes can potentially impact on the coastline dramatically.

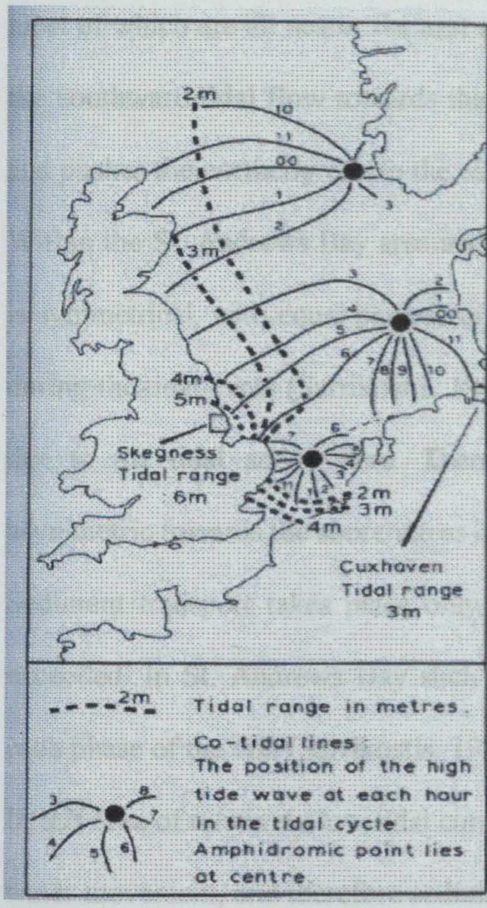


Figure 4.4: The Tidal System of the North Sea, (Pethick, 1984)

In addition, the coastal zone is constantly changing in response to the prevailing meteorological and hydrodynamic conditions, and to a large extent these forces are fairly predictable and a state of dynamic equilibrium will exist between the coastal environment and the prevailing forces.

Infrequent and largely unpredictable events can raise local water levels well above the predicted values and potentially cause drastic changes from which the coastal zone can take a long time to recover.

4.1.2 Tidal Activity and Tidal Currents in St. Andrews Bay

The study site is influence by the tidal activity of, the larger, St. Andrews Bay, which is part of the North Sea water body. The coastline here is influenced by changeable marine influences of tidal ranges, waves and currents, although St. Andrews, and in particular the East Sands, is afforded some shelter provided by the eastward extension of the coastal point of Fife Ness

The tidal range of the study site, i.e. the difference between the depth of water found at a location at successive low and high waters, has been recorded at between 5 and 6m (Ritchie, 1979, Robertson & Miller, 1997). And generally, it is agreed that tidal ranges along the east coast of the UK are greater than anywhere else in the North Sea (Goldberg, 1971). This is due to two factors: the amphidromic points of the North Sea, most of which are all nearer the east side, and the rotation of the Earth, which deflects the southward tidal flow towards the west, causing water to pile up along the coast, and pushes the northerly ebb to the east.

Within the St. Andrews Bay area and the open ocean of the North Sea, the tidal wave is symmetrical, with equal periods of rise and fall, and the flow direction can change during the tidal cycle (Sarrikostis, 1986). As a result there is no net transport of water due to the tidal action here. There is no firm evidence that the tide becomes asymmetric towards the shoreline as it does within the adjacent estuaries.

Sediment transport takes place only when the threshold for sediment transpor5t is exceeded. In St. Andrews Bay such conditions exist for relatively short periods on each phase of the tide (Sarrikostis, 1986).

In this area of relatively low tidal currents direct wind action, therefore, contributes to water movement, and therefore sediment transport. Within the study site the wind will drive water towards the shore throughout the tidal cycle with near-bed velocities that can exceed tidal current strength by two or three times, these extreme events can clearly have considerable impacts on sediment transport in the area, demonstrating northerly sediment transport in this beach zone (Ritchie & Mather, 1984).

The morphology of the seabed is influenced by the nature of its bedrock, the exposure of the area to wave attack and the supply of mobile sediment. Offshore the seabed slopes relatively smoothly to a depth of 50m, although periodically there are a number of banks and depressions ranging from 40m to 80m making the seabed slightly more irregular, this particular section of the continental shelf is the ultimate sink for the transient coastal sediments of the study site (Barne et al, 1997, Fugro, 1996). This makes the offshore topography of considerable importance as it will affect both the nature of tides and waves, but also their levels of potential energy and so influence what they do to the shoreline. The waters of St. Andrews Bay are relatively shallow, reaching depths of 20m, again (Sarrikostis, 1986), influencing the dynamics of both waves and tides upon reaching the shoreline.

The interaction of local atmospheric pressure with the prevailing wind and tide can usually lead to unusually high tides occurring all over the East Sands region. The St. Andrews Bay area has been known to experience tidal surges once every 50 years, with a height of 1.5 meters. While smaller surges occur more frequently the Spring Tidal Range alone often sits at 5 meters (Ritchie, 1979).

Therefore, with its high tidal ranges and the possibility that high-energy onshore waves could attack, it is not surprising that coastal defence works and sustainable harbour works have been compulsory, and a sustainable approach has been employed along this coastline for a number of years

In the study area the direct tidal influence of the North Sea, two such events are worthy of consideration – tidal surges associated with storm activity, tsunami events associated with earthquakes or submarine landslides.

4.1.3 Storm Surges

Storm surges generally occur with an amalgamation of strong onshore winds, building up coastal water to an exceptionally high level for a few hours or days, combined with high spring tides. The strong onshore winds also tend to generate large waves, which when accompanying the raised sea level, over-washing beaches, flooding low-lying coastal areas and generally cause extensive changes over a very short time period. Beach erosion during a storm surge tends to be severe, and can possibly change the morphology of a coastline permanently (Davies, 1972 & 1985)

Storm surges are well known phenomena in the North Sea area and are caused by both wind stress and pressure fluctuations, associated with the passage of depressions across the region. These low pressure depressions raise the elevation of the sea due to the barometer effect, and so a reduction in normal atmospheric pressure by 1 millibar will raise the sea level about 1 cm (Goldberg, 1971). Therefore, a fairly rapid change in the forces acting upon the waters of the North Sea i.e. first driven one way, then driven in the opposite direction, will cause the water to oscillate. This oscillation can resonate with the natural frequency of oscillation in the North Sea Basin, leading to higher tidal surges i.e. storm surges.

The most notable surge to affect the North Sea in recent years was that of the 31st Jan – 1st Feb 1953, when over 2500 lives in Holland and 300 lives in England, were lost through severe flooding. This event resulted from unusual meteorological events and affected areas in the UK were the Wash, East Anglia and the Thames Estuary, although areas as far north as the Tees Estuary experienced flooding (Lamb, 1991).

The meteorological conditions leading up to the surge included a period of strong winds from the southwest in the Atlantic, which pushed water masses towards the north end of the North Sea plus a depression 972mb, which would normally pass to the NW of Scotland, or pass up the English Channel. On this occasion, however, it took a much more southerly route from the north of Scotland and tracked southeastwards from Shetland towards Denmark (Lamb, 1991). Very strong, hurricane force, northerly winds swept down the North Sea as the depression crossed Scotland and then shifted to a predominantly southwesterly direction and finally to a northerly direction as the depression moved down into the North Sea across into Denmark on the 1st Feb. During the afternoon of the 31st gale force northerly winds moved some 15 billion cubic feet of water into the North Sea causing a rapid rise in the water surface elevation, which was then transmitted southwards as a huge surge wave. Further south at this time the wind was more southwesterly, causing water to pile up against the Dutch coast.

The surge wave took some 7 hours to travel from the Forth to the Thames Estuary increasing in elevation from some 0.9m at Leith, Edinburgh, to 2.5m at Sheerness, and although many sea defences were breached by this surge, the peak of it did not coincide with the time of the predicted high water and so elevations were actually less than the maximum possible (Lamb, 1991).

According to Hardisty (1994) and Pethick (1984) storm surges do not tend to move a great deal of sediment onshore, and return currents carry sediment seawards to become deposited offshore. Where flooding of the land surface behind the coastline occurs, this is not the case, and layers of storm surge related sediments are known in many North Sea coastal areas (Donaldson, 2003).

In the absence of surges the wave activity of industrial storm events may indue substantial erosion of sandy beaches, attacking dunes, re-configuring offshore banks and realigning navigation channels.

4.1.4 Storms and Storm Surges of the North Sea

The North Sea as a closed basin system and has a long record of storminess (Bruce, 1884 & Lamb, 1991). It is also one of the busiest shipping areas, so therefore is a wealth of information on the region. Studying the level of 'storminess' of the North Sea is important to gauge better the strengths, durations and extent and other features of storms including their energy sources and the controls upon their frequency. There is debate that the storminess of this region has increased since the 1950's (Goldberg, 1971, Lamb 1991). The North Sea is part of the most frequent storm tracks of the northern hemisphere, and is renowned for its storminess in particular from the history of storm flood disasters on its coastlines.

Appendix 4 is a detailed historical account of the North Sea storms that have affected the study site. Adapted from Lamb H (1991), ***Historic Storms of the North Sea, British Isles and Northwest Europe***, it is a historical investigation of great storms that have affected the North Sea, the British Isles and the fringe of Northwestern Europe. All the storms with serious effects, which could be identified within the last 500-600 years, are recorded and in every case, possible observations of weather and other relevant circumstances recorded. The analysis of this allows wind strength estimates and aids diagnosis of storm origin. It looks at trends and local variations as well as impacts on human affairs e.g. damage on to coasts, buildings, forests and other aspects of the landscape.

Storms examined by Lamb (1991) were compiled from records of great sea floods and other coastal disasters in recognised scientific collections e.g. Gottschalk (1971, 1975 & 1977), Gram-Jenson (1985), Peterson & Rhode (1977), and also taken from ***Meteorological Magazine***, Monthly Weather Reports of the Met. Office and ***Weather***, while some were found in local histories, archives, newspapers and port records.

The Appendix serves to illustrate that in general the St. Andrews Bay area has been subjected to many large-scale storm events. Some that have inundated the coastline, some that have damaged property and buildings, some that have cost lives, but all that have subjected the shoreline to high energy events, therefore affecting the localized morphology. Section 3.5.1, also further illustrates, through several newspaper reports, the shipwrecks that have occurred in the Bay, reinforcing the effect of storm activity on the study site.

4.1.5 Tsunamis

Storm surges are comparatively minor events compared to tsunamis, and in contrast are long period waves that exhibit higher onshore than offshore velocities leading to a net sediment movement landwards (Carter, 1988, Davies, 1997). Tsunamis are nearly undetectable in the open ocean because they not very high, and until they enter shallow water where they slow, their wavelength then compresses, and height increases. As a tsunami comes ashore there is an initial lowering of sea level followed by an uprush of huge amounts of water flooding ashore.

Caused by seismic activity or the collapse of underwater structures, they generally start off as low amplitude long waves, which build up in height as they move into shallow water. Although more common in the Pacific, and more recently the Indian Ocean, as the result of submarine earthquakes, they can still be caused by landslides of cliffs into the sea, or the collapse of sediments from the edge of the continental shelf down to the deep ocean floors. Water displacement brought on by the landslip or earthquake is propagated out from the source throughout the ocean as a wave motion. In the open ocean these waves are of low amplitude, perhaps less than 30cm and also of low frequency – with anything from between 5 and 90 minutes between each successive wave crests. The speed at which these waves disseminate across the oceans is high, up to 500km per hour, and upon entering shallow water the wave amplitude increases dramatically and at the shorelines can be several meters or occasionally tens of meters in height (Carter, 1988, Zenkovitch, 1967).

Large scale inundation of coastal lowland areas by tsunamis cause enormous damage to property and vegetation, while soft sediments such as dunes can be swept away by the large volumes of water moving across low lying ground. In addition to the erosion of the terrestrial environment, the subsequent deposition of marine derived sediments is also possible.

The widespread presence of these offshore marine sediments with terrestial deposits in many parts of the coast of Scotland and Northern England has been taken to indicate that tsunamis have impacted the North sea coastal margins in the past (Barne et al, 1997).

Several submarine slides have been recorded on the Norwegian continental shelf edge – the largest 'The Storegga Slide' comprises three events. The first before 30 000 yrs BP, whilst 2nd and 3rd events occurred sometime between 8 000 and 5000 yrs BP. The combined volumes of the second and third slides involved the displacement of some 1700 cubic kilometers of material (Beer, 1997), allowing conclusions to be drawn that timing of the second slide correlates with the time of the deposition of a marine sand layer in Scotland, and its formation thus attributed to the tsunami generated by that submarine slide. This sand layer can be found up to 4 m above existing high water marks (Ritchie, 1979). The tsunami wave train rapidly reduces in amplitude after the first ten or so waves, which also reduces the likely hood of remobilization of deposited sediments

4.2 Waves

On the majority of coastlines the dominant forces causing most sediment movement and erosion are those associated with wave activity. Waves essentially release their energy at coastlines, in the form of breakers, resulting in the diffusion of energy, but not actual water mass. Many of the erosional and depositional features of the world's shorelines form, and are modified by, the energy of incoming waves.

Waves are characterised in several ways, by their length (L), height (amplitude, H), velocity (rate of forward motion of peak, C), period (the interval of time between successive wave peaks passing the same point, T). The highest part of a wave is its wave crest, whereas the lowest point between the crests is the trough. Wave length is the distance between successive wave crests (or indeed troughs), wave height (H) is the vertical distance between successive crests and troughs, wave steepness the ratio between the height and the length, and wave velocity (C) the rate of movement of the wave (Pethick, 1984).

These properties, and the relationships between them, vary greatly depending on the nature of the mechanism generating the wave, the intensity of that generating mechanism and the environment in which the waves exists. Waves, and their energy, affect coastal areas by a number of processes; wind – by surface waves, displacement – through earthquakes, landslides and tsunamis, changes in atmospheric pressure – i.e. storm surges, and the gravitational forces of tides.

Waves are generated by wind blowing over the water surface, where energy is then transferred by friction from the air to the water surface, and small capillary waves develop. These small waves whose restoring force, the force which causes water above or below the mean sea level to be restoring to that level, is surface tension, disappear immediately when the wind stops blowing. Their presence roughens the surface, increasing friction between wind and water, allowing more energy to be transferred to the water body. If the wind continues to blow and strengthen this results in the production of larger waves, where the restoring force will now be gravity.

There are limits to the size of waves generated by winds blowing namely wind speed, wind duration and fetch – the distance over which the wind blows. Winds of a given speed will only produce waves of a maximum length and height, even if the wind blows over long ocean distances and over long periods of time. This is because larger waves cannot be generated as no further energy can be transferred to the water body. If the wind blows over a shorter fetch, say a lake, or for a shorter duration, the waves will not develop fully. Thus in open ocean, a given wind will produce larger waves the longer it blows, and larger waves where the fetch is large.

Waves also behave differently depending on the depth of water in which they are being developed. In the actual area where waves are being created, waves of all heights and lengths are generated. As the waves move out of the area of generation, the longer waves move faster and therefore progress further in a given time than the shorter ones – known as the 'separation of the spectrum'. And so the first waves to arrive at any site are thus the longer period waves followed by the shorter period waves. In addition to the separation of the spectrum, the shorter waves lose energy as they travel, and at distance only long period waves are present. These waves, known as swell waves, are important in beach processes, in that they are generally constructive in the beach zone.

Waves can also be classified as either deep water or shallow water waves, depending on the relationship of wavelength to water depth. Waves in water deeper than half the wavelength are categorised as deep-water waves, while those in water shallower than 1/20 the wavelength are shallow water waves. Both kinds of waves differ in what controls their height and speed. The speed, length and period of waves are inter-related. The height of a deep-water wave depends on its length and on the energy it contains from the storm that generated it. The wavelength limits the height because if the wave gets too tall it breaks, i.e. maximum height can only be 15% of the wavelength (Pethick, 1984).

In contrast, shallow water waves are influenced by the effect of contact the wave base has with the sea floor. As waves approach a shoreline, the orbital motion in the water column begins to 'feel' the sea floor, i.e. the contact with the sea floor restricts its motion. The orbits of the water particles become flattened ellipses and the wave starts to slow down due to the friction between itself and the bottom. When the wave is slowed, and its length is much less than it was before it hit shallow water, the wave gets higher and steeper, continuing like this until it breaks.

The speed of any wave depends on water depth, so the wave front will slow down differentially as it passes over uneven bathymetry e.g. over a differing bathymetry parts of the wave front will be lengthened, while others shorten, giving rise to variable heights along a wave front.

It is also worthy to note that deep-water waves can actually occur in shallow water, if their wavelength is short. Tsunamis and tides are examples of shallow water waves in the deep sea, in that their wavelength is very long compared to the water depth of any part of the ocean.

Thus waves are essentially undulations at the water surface produced by wind action. When waves begin to move across the surface of the sea they cause water movement to be set up in the water body, inducing orbital movements of the actual water particles. The degree of movement of the particles diminishes rapidly from the surface downwards through the water column, until the motion is very slight where the water depth (d) equals half the wavelength (L), this is the wave base (Pethick, 1984). At depths exceeding the wave base, the water and sea floor are unaffected by surface waves, hence many sea floor sediments being extremely smooth and untouched. The orbital motion of the water particles in a wave are not wholly complete, so that when the water particles move forward as each wave passes, that produces a slight drift of water in the direction of wave advance.

The distinction between waveform and water movement is an important one, waves are merely the shape of the water surface and wave movement is the movement of water particles themselves, inside the water column. It is the actual energy contained in that wave body that is then dissipated upon meeting a coast, but its geomorphic impact depends on a combination of its waveform and available coastal materials.

In most cases waves entering water less than half their wavelength in depth, will transform into breaking waves as bed friction destabilizes the orbital path of the water particles. This results in waves undergoing a transformation as they enter the shallow water of the shore zone; the changes in wave speed and length concentrate the wave's energy forcing it to increase its height. In effect, as the waves enter shallower water they become 'over steepened'; the waves crest advances faster than the waveform, until eventually the crest collapses or plunges forward as a breaker. When these breakers plunge forward, their kinetic energy is expended on the shoreline, and it is this energy that causes the changes in beach morphology, and so forming coastal landforms.

Waves breaking on a beach exhibit four distinct forms (Bird, 1969 & 2000, Davies 1997, Pethick, 1984 and Summerfield, 1991) - surging, plunging, collapsing and spilling. **Surging Breakers** - are low and gentle waves until they sweep up a relatively steep beach. **Plunging breakers** - have fronts that curve over and crash, producing little swash, but a strong backwash. **Collapsing Breakers** - subside as they move towards the shore, and **Spilling Breakers** – are short and high and produce foaming surf as the swash runs up a beach of gentle gradient.

In general surging, spilling and collapsing breakers have a strong swash followed by a gentle backwash producing a net shoreward movement of sediment. Plunging breakers, on the other hand, have a short swash and a relatively stronger backwash, so they tend to withdraw sediment from a beach. The breaking waves bring considerable kinetic energy of motion toward the beach, and turbulence of the beach sediment. It is this energy that causes the actual movement of sand and gravel. Waves breaking against a shore immediately interact with the beach sediment; each wave temporarily suspends sediment within it, which is then moved by the prevailing currents, primarily wave-generated, longshore currents. The water coming ashore returns to the sea in narrow zones called rip currents that can, depending on the type of breaker, be potentially destructive to the beach sediments.

The energy available to move sediment depends on the velocity, depth, turbulence (through swash/back swash impedance) and extent of percolation in this zone. In rough weather, higher and steeper waves tend to form plunging breakers, with collapsing crests, which produce less swash, but a more destructive backwash, which scours sediment away from the beach, transporting it offshore where it is stored in sandbars. In calm weather, low waves tend to form spilling breakers with a constructive swash, which moves sand or shingle on to a beach to build up a berm parallel to the shoreline (Bird, 2000, Pethick, 1984). This same sand eroded from the beach during winter storms returns the following summer when it is driven onshore by more gentle swells. This resulting alternation between scouring and berm building is known as 'cut and fill' (Pethick, 1984), and can be directly linked in some locations to seasonality of climate. The volume of sand in the system remains more or less constant, it simply moves on and off shore depending on wave energy.

Wave transformations in shallow water can lead to a process called wave refraction. This is where the shape of the coastline and offshore bathymetry leads to variations in the concentration of wave energy at different points along a shoreline. Waves in general do not approach the coastline orthogonally, i.e. with their wave crests neatly parallel to the shore, but tend to be driven obliquely onshore. The wave body will also not encounter the sea floor simultaneously along its length, leading to a process known as 'wave refraction' i.e. the changing direction of a series of waves moving in shallow water at an angle to the shoreline. Wave refraction is the wave realigning itself parallel to the sea floor contours, upon contact. Waves will therefore be retarded around headlands but drive on less impeded into bays. Such refracted waves alter the energy patterns at a coast, resulting in energy convergence around headlands and divergence in bays (Dutch et al, 1998, Skinner & Porter, 2000). The net tendency of these contrasting effects will, in the course of time, make an irregular coastline smoother and less indented.

4.2.1 Waves in St. Andrews Bay

There is little measured data on wave activity in the area, but it can be gleaned that waves in the study site are chiefly generated by winds from the north and east (Ritchie & Mather, 1984), meaning the coast predominantly experiences easterly storms. The offshore zone is characterised by relatively smooth bottom topography meaning very little refraction takes place. The waves approach the shore at an oblique angle, from anything between 15° and 20° (Lamb, 1991), driving a northward movement of sediment. The surface sediments of the Bay are mainly fine sands whose longshore drift northwards is restricted by the two breakwaters at the harbour mouth. This leads to an accretion of sands, muds and silts in and around the southern side of the harbour entrance. Whereas, in comparison, the north side of the main pier experiences severe pressure during storm activity, it is exposed to the full forces of the North Sea waves, as it has no protective sediment layer.

The East Sands experience spilling, collapsing and surging breakers throughout most the year, but generally endures plunging breakers through the winter months, therefore seasonally tending to experience a very stormy and destructive winter time. Despite this cyclical lowering of the beach sediment, which can expose shingle, bedrock and various pipe work, there is a defined limit to the erosion as the sands are underlain by stable glacial clays (Omand, 2000, Robertson & Miller, 1997).

4.3 Currents

Sediments produced as a result of wave action, or brought to the sea by rivers, are redistributed thanks to currents in the nearshore zone. These are responsible for distinctive shoreline deposits and the actual physical movement of sediment on and offshore. The process of waves breaking in a shoreline environment, send pulses of water shorewards until they run out of momentum, whereupon gravity pulls them back into the sea. The resulting turbulent water-sediment exchange brings maximum geomorphic activity, whereby the water body picks up the sediment particles, and the currents then move it on.

The most prominent current, conducive to sediment movement, is the longshore current. Despite the power of refraction, waves still reach the shore at an angle, and can be divided into two directional influences; one orientated perpendicular to the shore, and the other orientated parallel to the shore. The perpendicular motion produces the crashing surf in the nearshore zone, whereas the parallel component sets up the longshore current that flows parallel to the shore. And so, as the surf erodes sediment at the shore, the longshore current then picks up and moves the sediment along the beach, making longshore currents imperative to the transportation and deposition of sediment in the nearshore zone (Briggs, 1998).

This longshore current is made of two distinct processes that both influence the coastal zone. Together they have varying strengths and directions, but it is the interaction of these two that mobilize and carry the sediment. For the purposes of investigation they can be separated into two categories - shore-normal and longshore currents.

The onshore-offshore movements of the water particles within the waves produce currents that develop at right angles to the shoreline; these are shore-normal currents. The potential energy of these waves is constantly being transformed into kinetic energy and back into potential energy as the wave moves forwards and backwards. As the wave transforms upon reaching shallower water, the orbital oscillations of those water particles are modified and means that the formation of shore-normal currents that can vary in magnitude and duration as the water depth decreases.

As previously established, wave crests arrive at the shore at a slight angle, the driving force of which is the wave-energy arriving in the near shore zone, resulting in both oscillatory and steady mass transport. A wave-induced longshore current will flow parallel to the shore and run aligned with the direction of the prevailing winds, and the greater the angle of the incoming waves on a shore, the greater the rate of longshore movement. It attains its maximum velocity when the waves approach the coast at an oblique angle of about 30°. If the tidal current flows in the same direction the longshore current will be strengthened but if it flows in the opposite direction the current will be obliterated. (Pethick, 1984)

Connected to this then is the theory of longshore drift. It is agreed that localised currents constantly redistribute the sediments produced within any coastal system (Dutch et al, 1998, Skinner & Porter, 2000). This builds up distinctive shoreline deposits or moves the sediment offshore onto the continental shelves Primarily this is influenced by the phenomena of longshore drift i.e. waves reaching the coastal margins tend to on an oblique angle, this sets up a longshore current within the surf zone that flows parallel to the shore (i.e. along the shore).

Consequently the swash of each wave travels obliquely up the beach before gravity pulls the water back directly down the slope of the beach. This zigzag movement results in progressive transport of sediment along the shore, a process known as beach drift i.e. surf rushes up a beach with each incoming wave, sand grains are picked up and carried shoreward. Arriving surf approaching the shore at an angle will travel obliquely up the beach. The return flow, pulled by gravity, flows back nearly perpendicular to the shoreline. A grain of sand will move along a zigzag path as successive waves reach the shore.

Plunging breakers are the most dramatic and mobilising waves. The breaking wave applies hydraulic shock or a 'hammer effect' to the surrounding water body. By trapping water and compressed air ahead of the wave, creating a vortex just below its breaking tip, the compressive stress is maximised as the wave plunges downwards, trapping air between crest and troughs. This is powerful enough to penetrate the trough ahead of the wave and scour the seabed, throwing up a cloud of sediment and trapped air bubbles clearly visible behind the crest. Continued coastal erosion occurs through repeated hydraulic action and the subsequent mobilisation of those affected sediments (Pethick, 1984). A plunging breaker combined with a longshore current can entrain and move great quantities of sediment, not only daily, but is particularly most effective under storm wave conditions.

Chapter 5

Methodology and Analysis

In essence this project was designed to pool information on the constantly changing shoreline at the East Sands, St. Andrews, by collating data on the changes and prevailing conditions affecting the beach profile. Looking at, and understanding, a beach profile allows you to compare changes over a chosen timescale. The research represents an attempt to create a full understanding of the coastal morphodynamics of the study site. It was decided that data on beach profiles transects of the East Sands, local climatology, storm history and historical shoreline development were to be assembled in an attempt to compile a full picture of the evolution of the study site.

5.1 Beach Profiles

As previously established, the processes in the nearshore zone that induce erosion and the creation, transport and deposition of sediment, will transform the morphology of a coastline. At any given time both the geometry of the shoreline and the shape of the shore profile represent a compromise among the constructive and destructive forces acting along that coast. We know that beaches are important features in a coastal environment, they can be viewed as an effective natural mechanism that cause waves to break and dissipate their energy. The beach, therefore, serves as a buffer against incoming wave-energy for the coastline, and is important agent protecting against erosion. If there is long term loss of sand from the beach, the beach will be increasingly less capable of serving as a buffer and erosion will become more progressive and probable. So consequently, the shape of any beach constantly changes in relation to the prevailing conditions of its environment.

Definition of a beach profile has been described as either of the following.

1. **Extending from low water of spring tides to the upper limit of wave action.**
2. **Including the seaward zone over which sediments can be moved by waves, stretching from the landward limit of wave action to water depths of 10m to 20m at low tide.**

However, both definitions fail to be completely comprehensive. The first definition fails to encompass the dynamic zone over which the beach sediments may move, it only includes the portion of the beach that can be seen. The second definition also fails to recognise that the limits of the profile are forever changing due to both changes in wave characteristics and also throughout the tidal cycle as water depth changes. For the purposes of this study then, the profile data were gathered using definition one as the boundary, while theoretical consideration has been granted to include the limits of definition two.

The overall profile of any beach and its adjacent nearshore zone depends on several factors; sediment supply, wave climate, overall slope of the continental shelf, tidal range, and variety of subtle local conditions, making the morphology of beach profiles infinitely variable. It is, however, generally recognised that there are two distinct classes, or types. These are the 'summer/winter' profiles (Komar, 1976), also known as 'storm/normal' or 'storm/swell' profiles. The terminology used describes the environmental controls of both profile types, not their morphological distinctions as it is widely argued that shifts in profile correspond with seasons of summer and winter.

The 'summer' Profile

Summer profiles are characterised by a wide berm and a smooth offshore profile (Figure 5.1). A result of fair weather and a low energy environment, it generally includes a swell wave with a low wave height (generally <1m) with a period of 8 - 12 seconds (Pethick, 1984). This produces, what is known as, an 'accretional' beach, with the predominant mechanism here the deposition of sediment. Erosion is absent or very limited.

Accretional beaches have a wide, well-developed back beach and relatively narrow steep foreshores, with well-developed sandbars. The transition of a beach profile from a steep to a shallow gradient is marked by the removal of the berm and the deposition of a bar just below the low-tide level - the 'longshore' bar. Summer beach profiles also may possess a pronounced break in slope at the position of the breaking waves - the beach step.

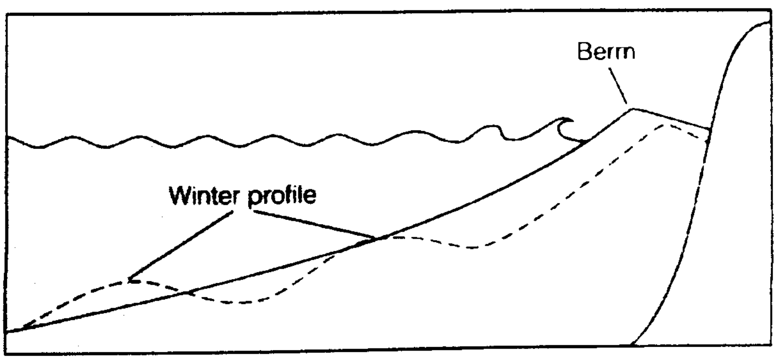


Figure 5.1: A 'summer' Beach Profile shown in contrast to a 'winter' profile, (Dutch et al, 1998)

The 'winter' Profile

In contrast a winter profile has almost no berm, the sand having shifted offshore to form a series of bars parallel to the shoreline (Figure 5.2). This is a result of turbulent/stormy weather in a high-energy environment, tending to result in erosive beaches. In general the overall profile tends to be smaller in the winter then in the summer. Storms, although short in duration, are the dominant physical processes along the vast majority of coasts.

During a typical storm, there is an increase in wave size, where sediment is then entrained, and the accompanying currents readily carry it away, both offshore and along shore. The removal of this sediment produces an erosional profile, or 'storm profile'. The back beach is now narrow, sometimes even absent and the nearshore bars move much further offshore (up to 10-20m).

Storm profiles are generally temporary, and in the absence of more storms a recovery period begins, characterised by the return to low-energy wave conditions. As swell and small waves resume, landward transport of sediment returns the nearshore bars to their original positions. The occurrence of frequent and severe storms can remove entire beaches, exposing their bedrock. This can persist for several months until the lower wave energy conditions of spring/summer return.

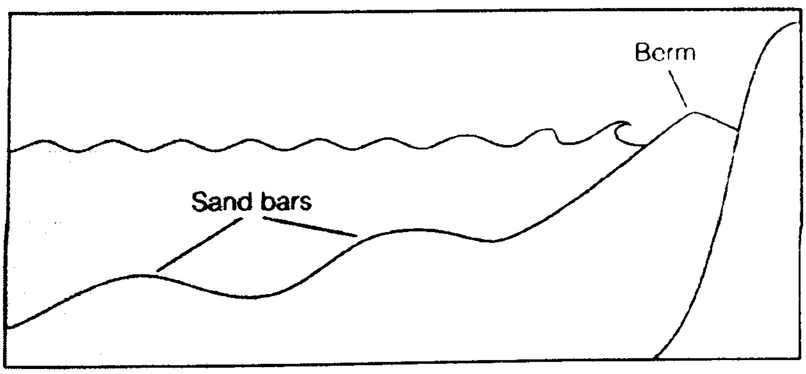


Figure 5.2: A 'winter' Beach Profile, (Dutch et al, 1998)

We can conclude, in theory, then that storminess may be seasonal, resulting in seasonal changes in beach profile, and although volumes of sand shift from the 'summer' berm to the 'winter' offshore bar and back again, they should remain fairly constant.

Beach profile variations are controlled by three main factors; waves - variation in wave energy, steepness or breaker type, sediment variability and the interaction of waves and sediments i.e. the sediment transport processes. This study highlights the importance of both wave energy and the transport of sediments at the East Sands.

Close relationships exist between wave type and beach profile gradient. The low flat swell waves present during the summer period build up the berm and the beach face progrades seawards forming a steep profile. During the winter months the high steep storm waves found will erode the beach face and transport the sediment seawards where it will form a longshore bar, the beach profile will then widen accordingly and its overall gradient is reduced.

To quantify the effect of waves on the beach profile, it is beneficial to separate wave type into two extremes – 'steep waves' associated with spilling breakers and 'flat waves' associated with surging breakers. The energy force of a wave is directionally proportional to its height, while the rate at which energy arrives at the coast is related to the wave period, and so, beaches receive high-energy inputs at a rapid rate under steep waves, but low energy inputs under flat waves. The morphology that the shoreline then adopts counteracts these influences; high and rapid energy inputs are best dissipated by a wide flat beach profile that will spread the oncoming wave energy out so that each unit of beach need only dissipate a small proportion of this incident energy, in contrast the low energy inputs of flat waves are easily dissipated by a narrow steep beach which acts rather like a wall on which the wave founder. Thus, wide and flat beaches characteristic of the summer months, and high steep beaches characteristic of the winter months.

The process of sediment transport plays a profound part in the changes of any beach profile. The repeated movement of sand across beach profiles results in sediment sorting; the higher the onshore velocities, and shorter the duration's of waves, both large and small particles will be moved in an onshore direction. In contrast, lower offshore velocities will only return finer materials seawards

In previous chapters it has been firmly established that beaches can both adapt their shape very quickly to changes in wave energy and also dissipate this energy in minor adjustments of the position of each sand, or shingle, grain. The beach is therefore able to strive to maintain itself in an equilibrium state with its environment, due to the inherent mobility of its sediments. It is this change that has been monitored at the study site with the specific purpose of assimilating profile change to environmental forces.

5.2 Data Collection

Taking repeated survey transects at fixed locations on a beach and comparing them, illustrates both long-term and short-term systematic changes and fluctuations in the profile. The data were collected at spring tide on approximately a monthly basis over a two-year timeframe, from March 2001 to February 2003 inclusive, to determine whether the beach material and energy inputs to the East Sands combine to produce equilibrium profiles, which ideally adjust to prevailing waves of the St. Andrews Bay environment.

Surveys were collected at ten transects (Figure 5.3) along the beach using a Lecia 530 Geodetic GPS System. The system uses precise satellite navigation arrangements to establish fixed locations anywhere on the earth's surface, determining positions as latitude, longitude and elliptical heights. The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude).

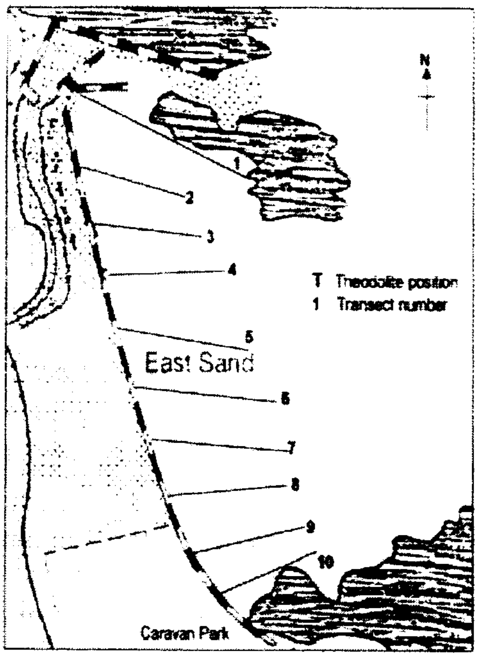


Figure 5.3 East Sands Transects, (adapted from Brown, 1997)

In operation two stations are used - a reference or base station – and a rover station that is moved while collecting the transect data. The base station sends corrections to the rover station and in doing so achieves a 1.5cm horizontal accuracy and 3.0cm vertical accuracy. Data are recorded in memory on the machine and downloaded onto a PC to the SKi-Pro software for post-collection processing. This involves determination of the exact location of the reference station using satellite data from the Ordnance Survey, and thus correction of original data to the corrected reference station. Information at this stage is in WGS84 latitude, longitude and elliptical heights. The data are then processed through the Ordnance Survey conversion program 'Grid Inquest' to transform it into British grid coordinates and elevations above OD. Data are then processed to give a text file and read into an Excel program to convert to an Excel file.

These Excel files (Appendix 1) were then run through the Surfer 7 Golden Software package in order to produce contour and shaded relief maps of the study site. Surfer is a contouring and 3D surface mapping program that runs under Microsoft Windows. It converts the Excel data into a variety of maps, and in this case contour and shaded relief maps.

The contour maps produced in Surfers allows full control over all map parameters, meaning that these contour maps could be controlled to highlight chosen contour intervals, in this case between –2.5m and 5.0m.

The Shaded Relief maps create a shaded map using different colours to indicate surface slope and slope direction relative to a user-defined light source direction, the light source can be thought of as the sun shining on a topographic surface. This highlights any surface undulations, and emphasises any changes in sediment distribution, along the beach face itself.

The Surfer 7 program was also used for a further two applications – the function of 'slice' and 'volume' Slice allows you to pick out a single transect and produce a profile of the beach face on a graph, in essence showing the 'shape' of the profile, highlighting the changes and movements of the sediments. This is done using a blanking file that allows the Surfer programme to extract both the beginning and ending points of each transect, within the survey data. From there, Excel is used to plot this data into line graph, effectively portraying a cross section of the beach face along the transect. Representative profiles were chosen to be included in the results, normally from the middle portion of the East Sands – roughly transects 5, 6 & 7.

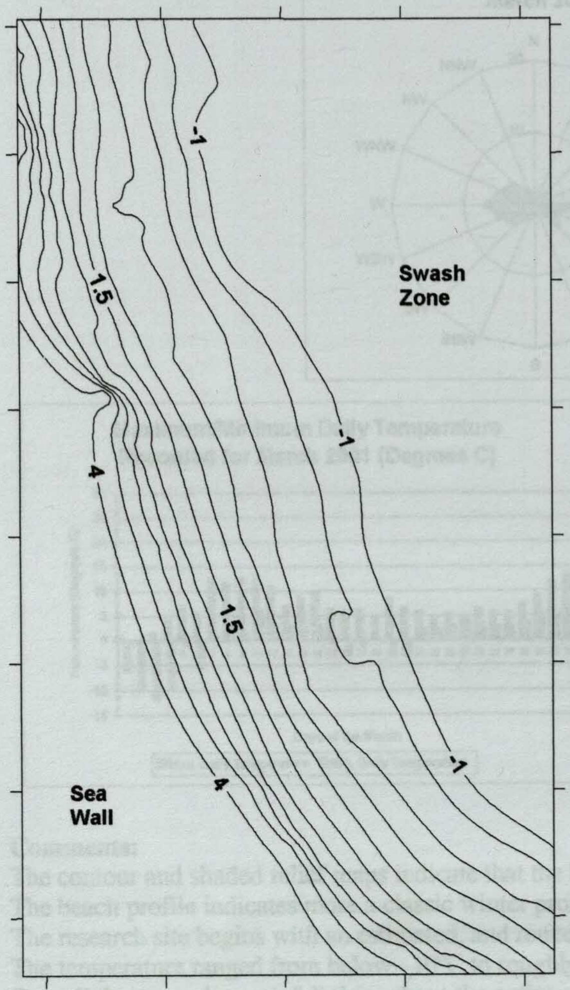
The function of 'volume' permits computation of the volumes of sand that are both moving on and off the East Sands between data collection times.

The results have been compiled so that all pertinent information gathered, for each month of the research period, is displayed together – for each collection time contour maps, shaded relief maps, slice/beach profile, volume and prevailing weather conditions (temperature, rainfall, wind speed, wind direction) have been pulled together.

Although there appear to be gaps in the data collection, in that not every consecutive month in the study time has data collection (these being April 2001, April 2002, July 2002 and October 2002), this is a result of a six-week gap, between surveys, rather than a usual four week gap.

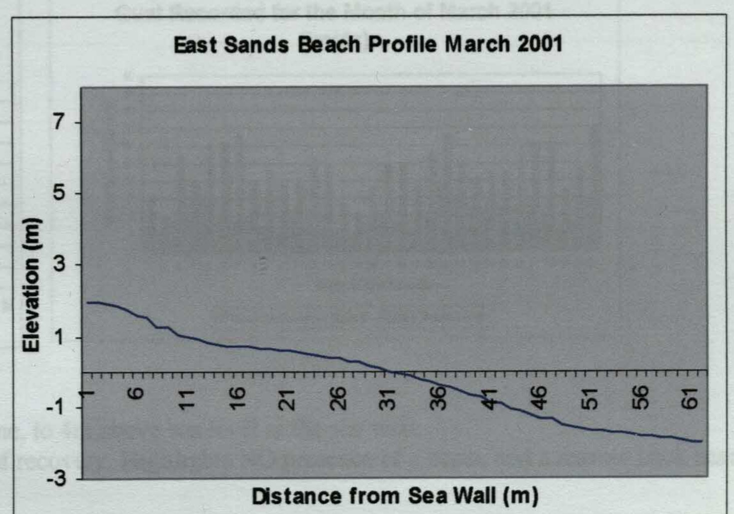
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

MARCH 2001

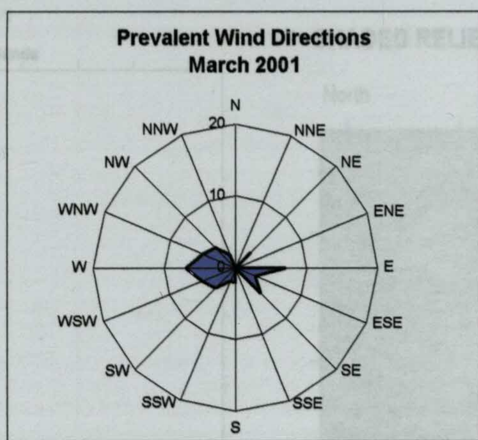


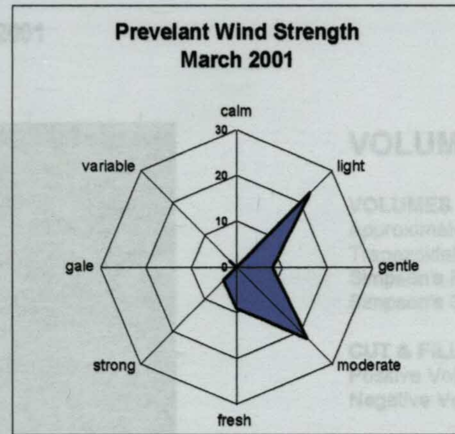
VOLUME COMPUTATIONS (m³)

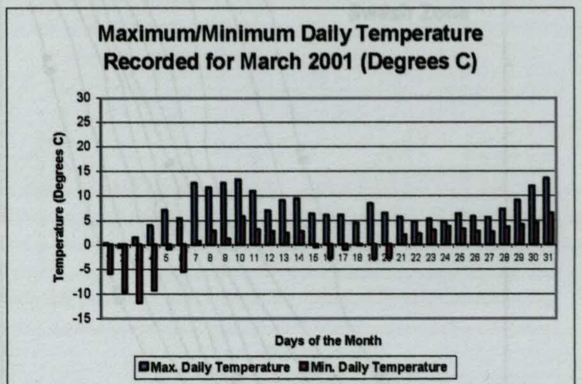
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**212589.470**
Simpson's Rule:	**212567.905**
Simpson's 3/8 Rule:	**212566.250**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**501078.164**
Negative Volume [Fill]:	**288488.909**
Cut minus Fill:	**212589.255**

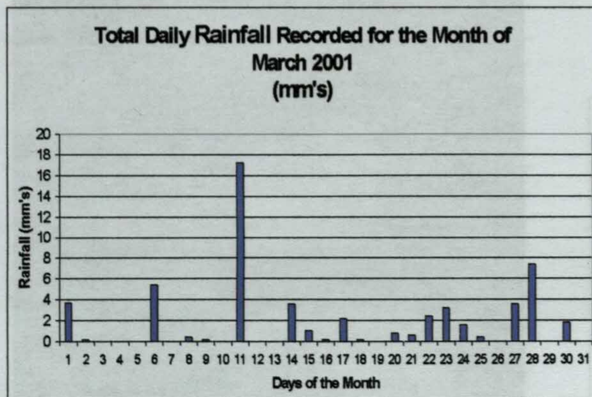


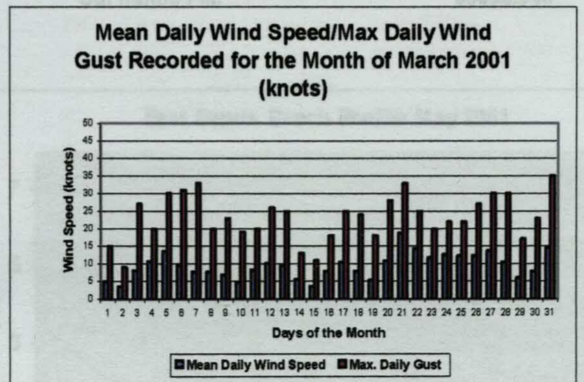
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











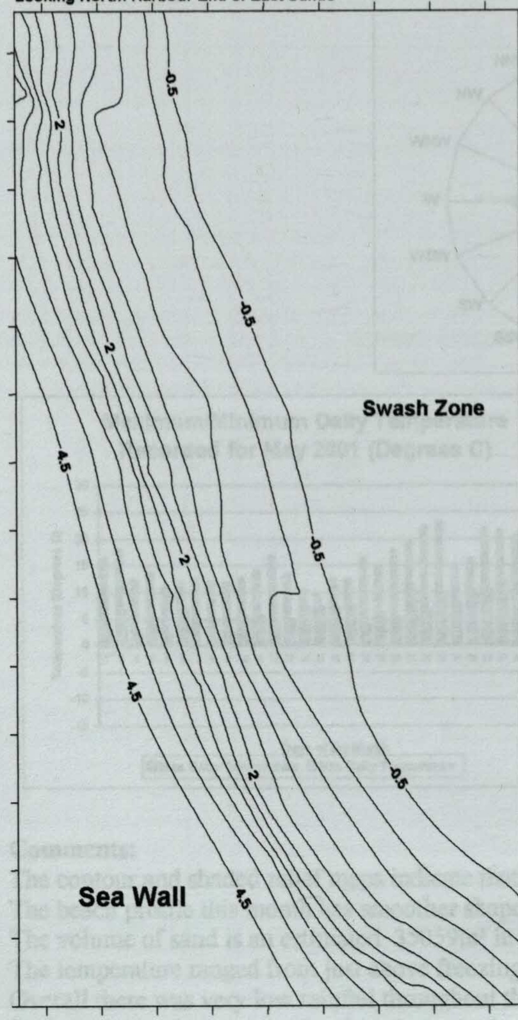
Comments:

The contour and shaded relief maps indicate that the beach face rises from –1m below sea level in the swash zone, to 4m above sea level at the sea wall.
The beach profile indicates more a classic winter profile shape than a summer one, although starting a process of recovery. Highlights NO presence of a berm, and a narrow back beach
The research site begins with an estimated, and rounded up, 212589 m^3 volume of sand.
The temperature ranged from below –10°C to roughly 14°C.
Overall there was low rainfall throughout the entire month, ranging from 0mm to 17mm falling in any one day.
The wind direction was predominantly westerly, with incidence of both easterly and southeasterly at times.
The wind strength varied from light, through gentle to moderate – roughly between 1-16 knots in speed.
The Beaufort Force would have been between 1 and 4, meaning incidence of small waves, large wavelets and crests.

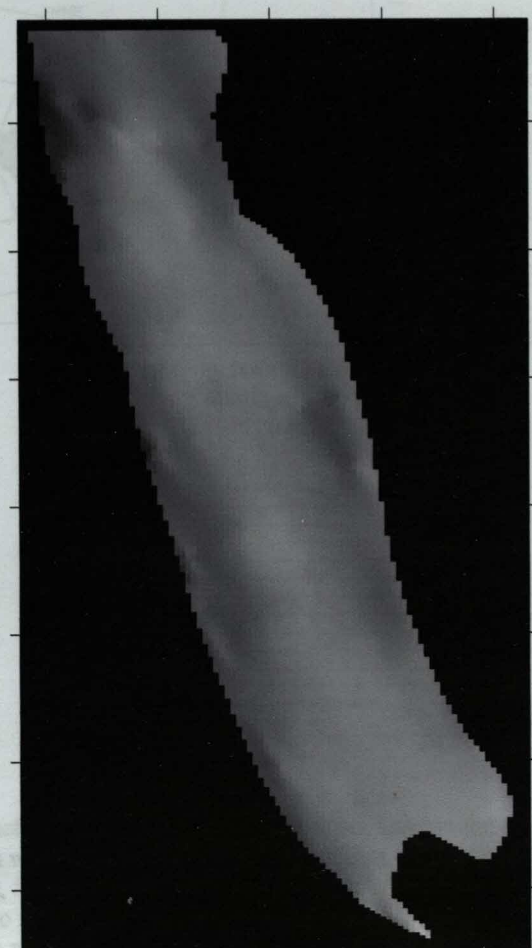
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

MAY 2001

CONTOUR MAP 8th May 2001

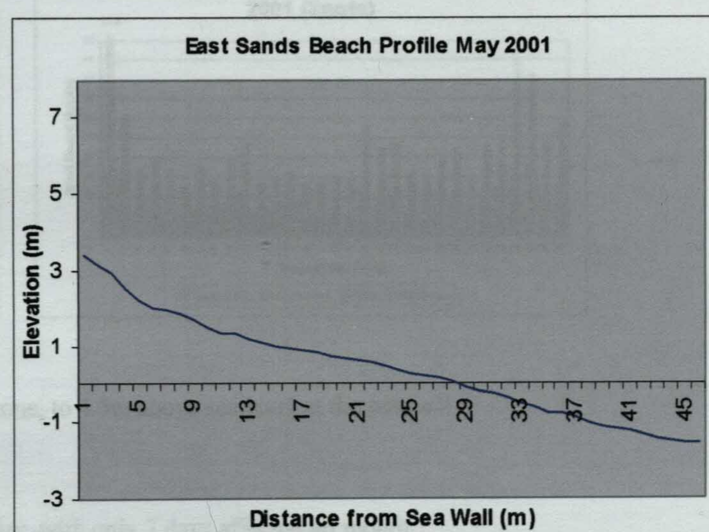


SHADED RELIEF MAP 8th May 2001

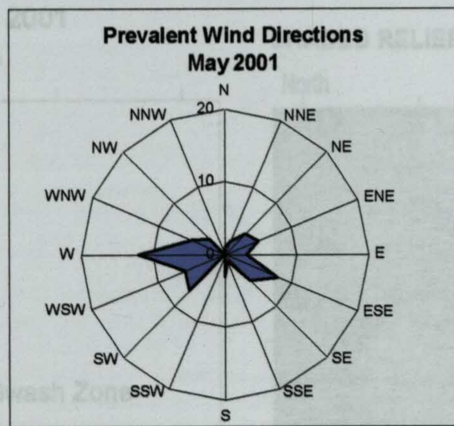


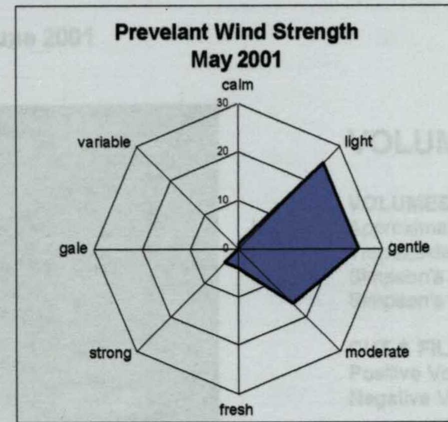
VOLUME COMPUTATIONS (m³)

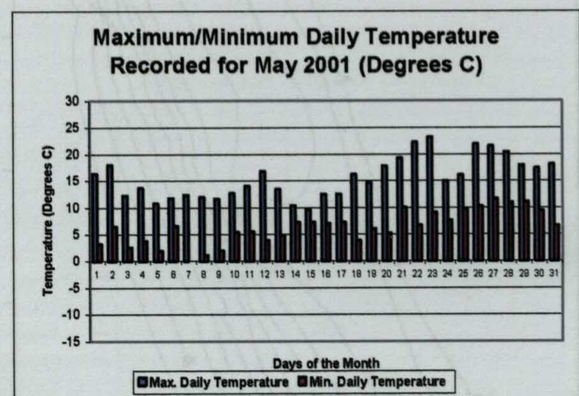
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**35058.940**
Simpson's Rule:	**35145.175**
Simpson's 3/8 Rule:	**35152.627**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**83869.289**
Negative Volume [Fill]:	**48810.349**
Cut minus Fill:	**35058.940**

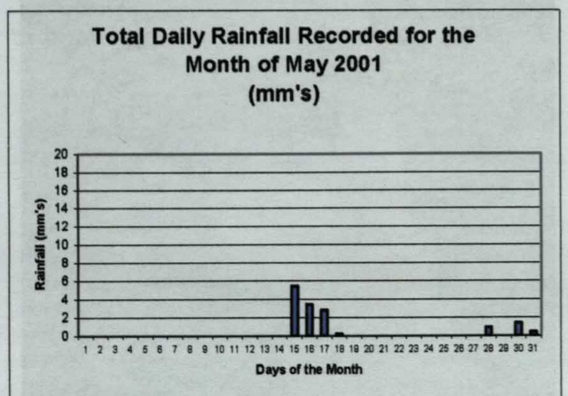


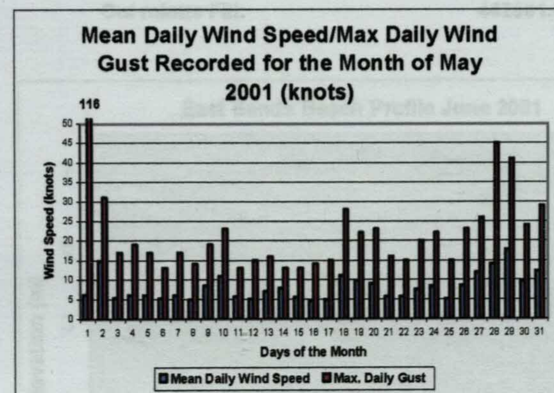
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

The contour and shaded relief maps indicate that the beach face rises from –0.5m below sea level in the swash zone, to 4.5m above sea level at the sea wall.

The beach profile this month has smoother shape, with a wide back beach and the beginnings of a berm.

The volume of sand is an estimated 35059m³ in volume, increase from the month of March.

The temperature ranged from just above freezing point to roughly a maximum of 23°C.

Overall there was very low rainfall throughout the entire month, ranging from 0mm to 5mm falling in any one day, with only 7 days affected all month.

The wind direction was predominantly westerly and southwesterly, with distinct occurrence of both north easterly and east south easterly at times.

The wind strength varied from light, through gentle to moderate, with some incidence of strong – roughly between 1-27 knots in speed.

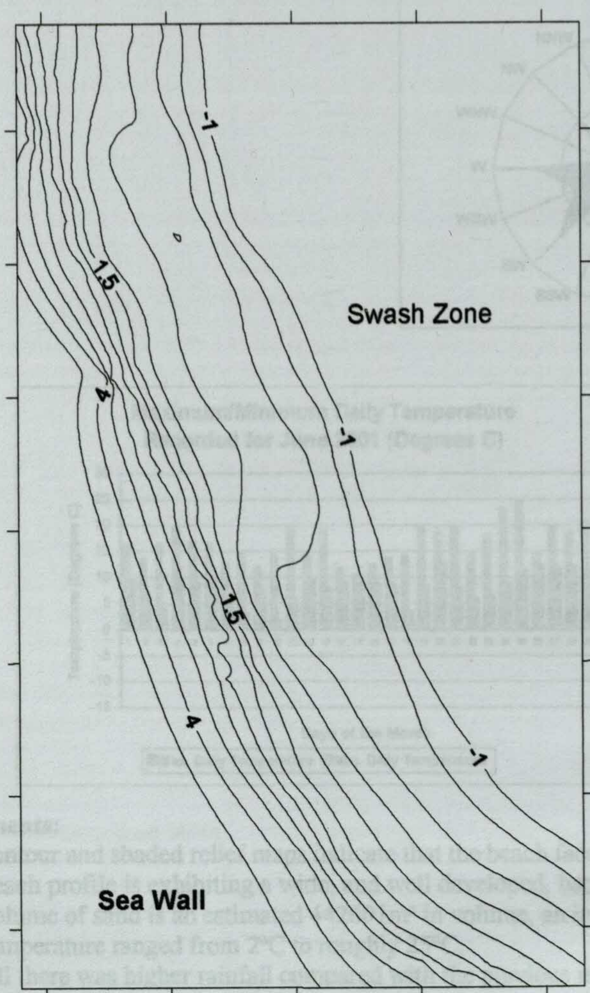
The Beaufort Force would have been between 1 and 6, meaning frequency of large, driving waves, moderate and small waves, large wavelets and crests.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

JUNE 2001

CONTOUR MAP 7th June 2001

Looking North: Harbour End of East Sands



Looking South: Kinkell Braes End of East Sands

SHADED RELIEF MAP 7th June 2001

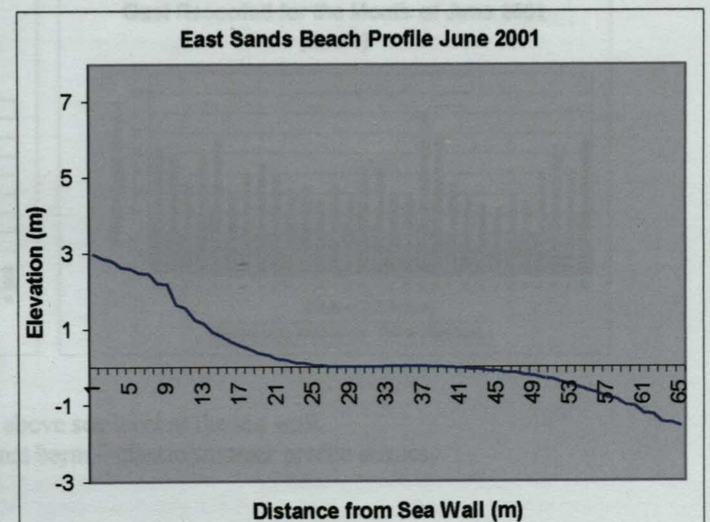
VOLUME COMPUTATIONS (m³)

VOLUMES

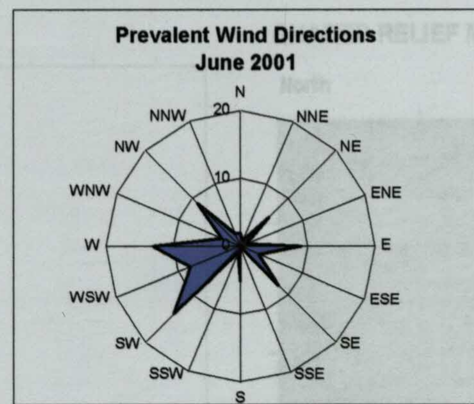
Approximated Volume by	
Trapezoidal Rule:	222592.796
Simpson's Rule:	222518.070
Simpson's 3/8 Rule:	222498.092

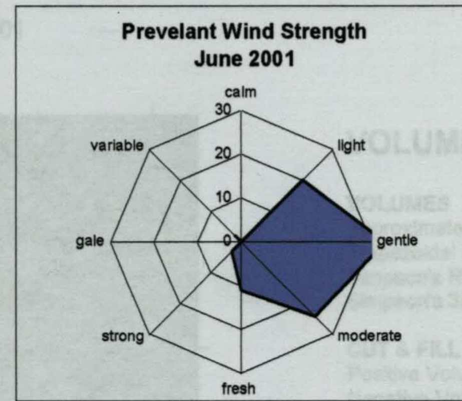
CUT & FILL VOLUMES

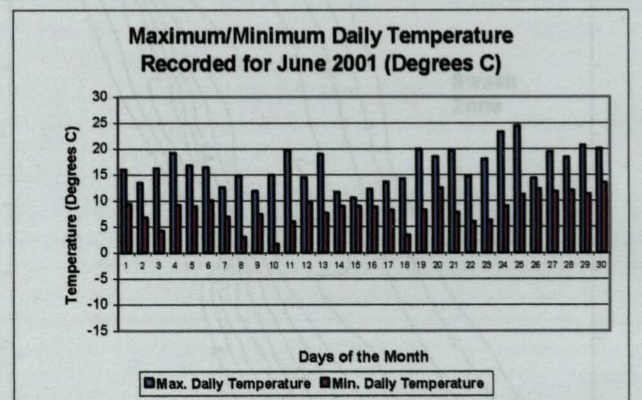
Positive Volume [Cut]:	776395.935
Negative Volume [Fill]:	333794.837
Cut minus Fill:	**442601.098**

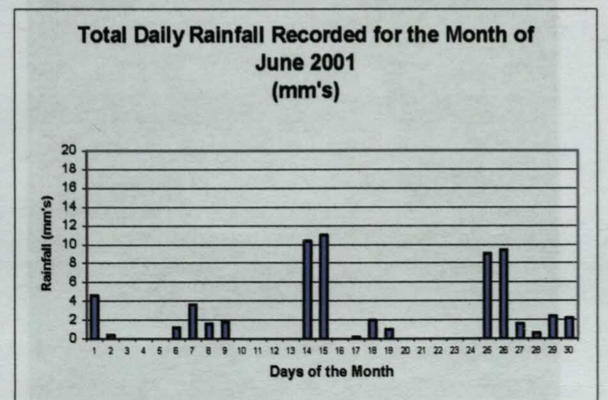


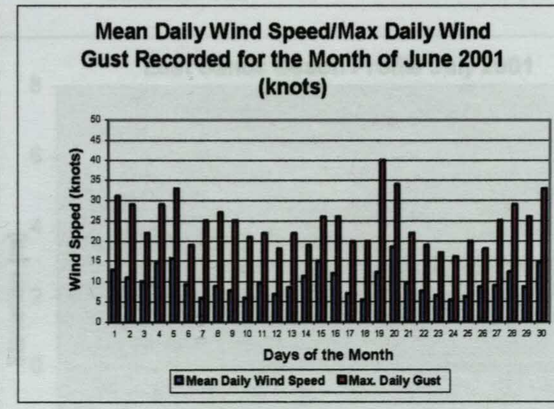
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS









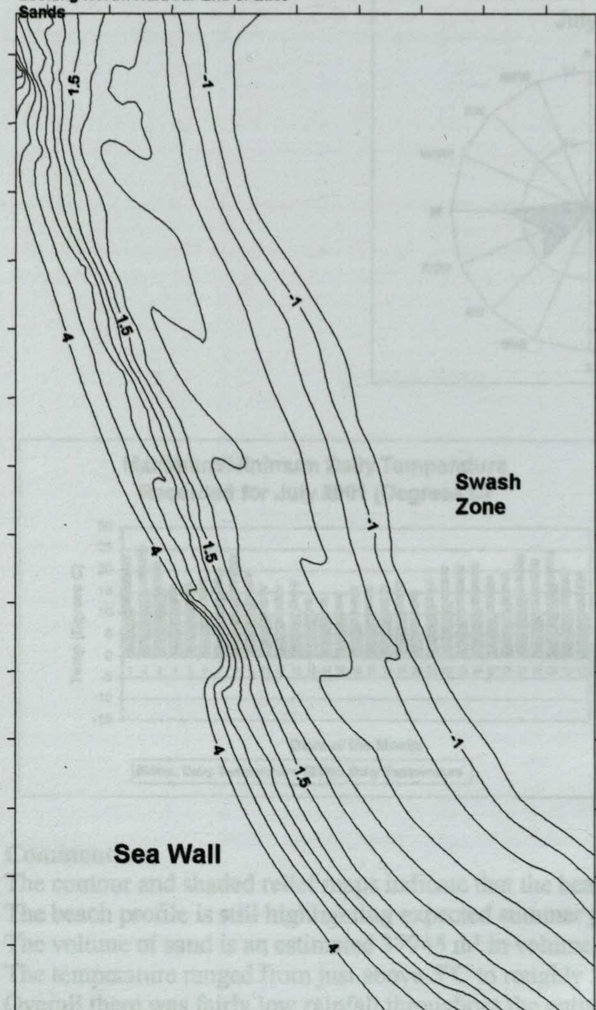


Comments:

The contour and shaded relief maps indicate that the beach face rises from –1m below sea level in the swash zone, to 4m above sea level at the sea wall.
The beach profile is exhibiting a wide, and well developed, back beach coupled with a narrow steep foreshore and a distinct berm – classic summer profile shapes.
The volume of sand is an estimated 442601m³ in volume, an increase from the previous month.
The temperature ranged from 2°C to roughly 25°C.
Overall there was higher rainfall compared with the previous month, ranging from 0mm to 11mm falling in any one day, and 17 days were affected.
The wind direction was predominantly westerly, south and northwesterly, but with frequency of both easterly and south-easterly at times.
The wind strength varied from light, through gentle to moderate, with fresh and strong strengths at times – roughly between 1-27 knots in speed.
The Beaufort Force would have been between 1 and 6, meaning incidence large and moderate waves, spray plus small waves, large wavelets and crests.

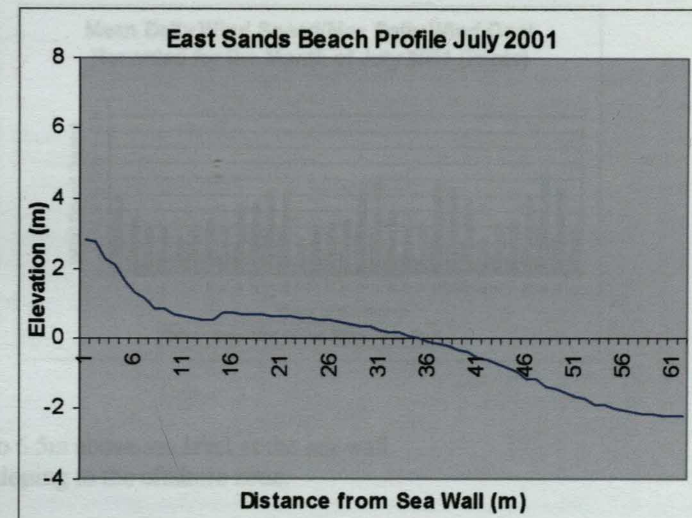
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

JULY 2001

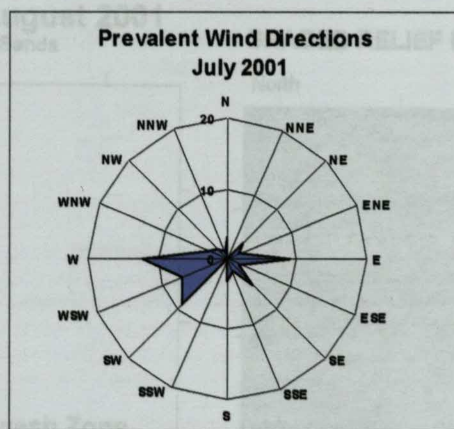


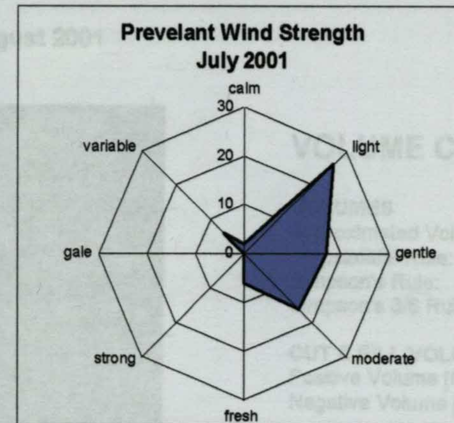
VOLUME COMPUTATIONS (m^3)

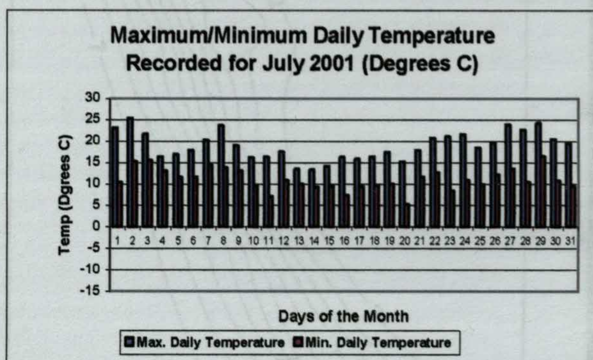
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**37744.931**
Simpson's Rule:	**37852.938**
Simpson's 3/8 Rule:	**37824.668**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**87656.167**
Negative Volume [Fill]:	**49911.236**
Cut minus Fill:	**37744.931**

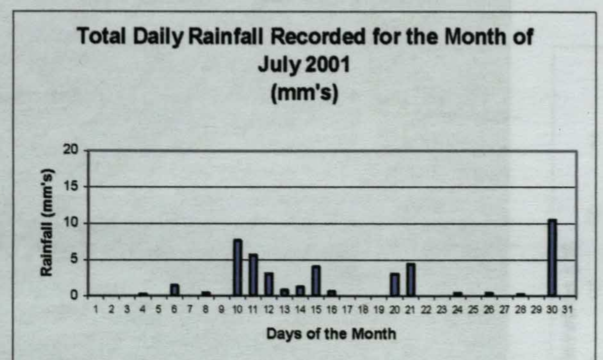


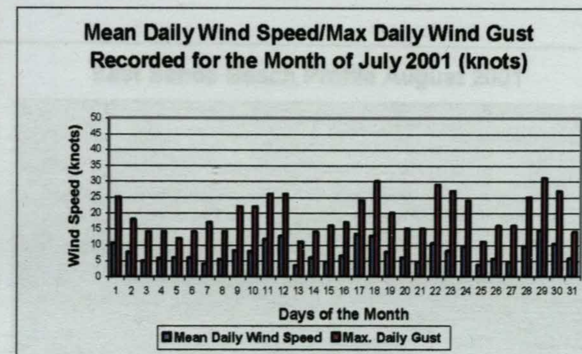
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











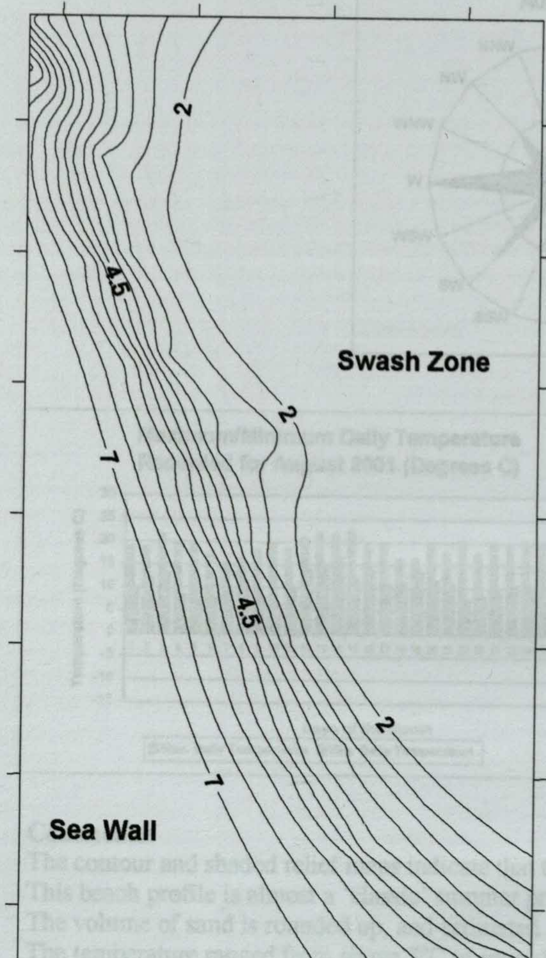
Comments:

The contour and shaded relief maps indicate that the beach face rises from –1m below sea level in the swash zone, to 6.5m above sea level at the sea wall.
The beach profile is still highlighting expected summer profile shapes – berm, steep foreshore, smooth topography sloping to the offshore zone.
The volume of sand is an estimated 37745 m^3 in volume, a slight decrease from the previous month.
The temperature ranged from just above 5°C to roughly 27°C.
Overall there was fairly low rainfall throughout the entire month, ranging from 0mm to 11mm falling in any one day, with 16 days being affected.
The wind direction was predominantly westerly, with occurrence of both easterly and south westerly at times.
The wind strength varied from light, through gentle and moderate to fresh – roughly between 1-21 knots in speed.
The Beaufort Force would have been between 1 and 5, meaning an incidence of moderate to small waves, large wavelets and crests.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

CONTOUR MAP 28th August 2001

Looking North: Harbour End of East Sands

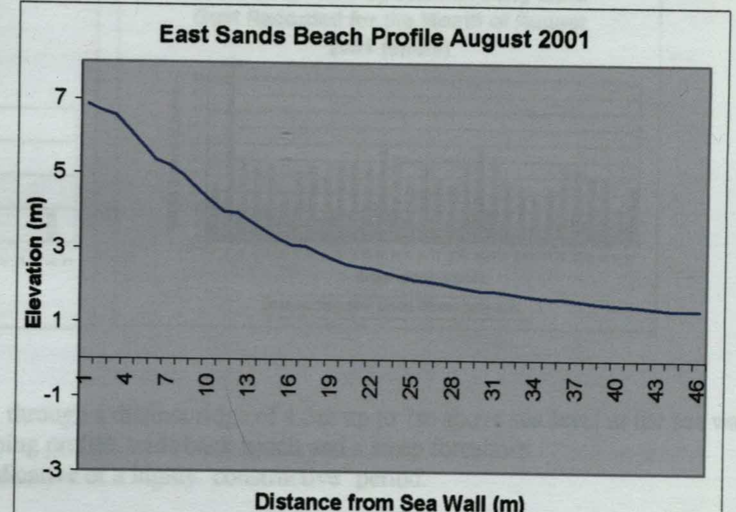


Looking South: Kinkell Braes End of East Sands

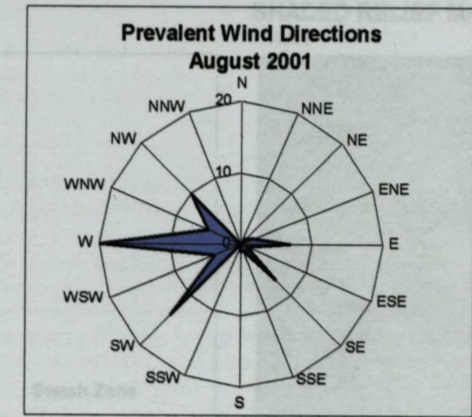
SHADED RELIEF MAP 28th August 2001

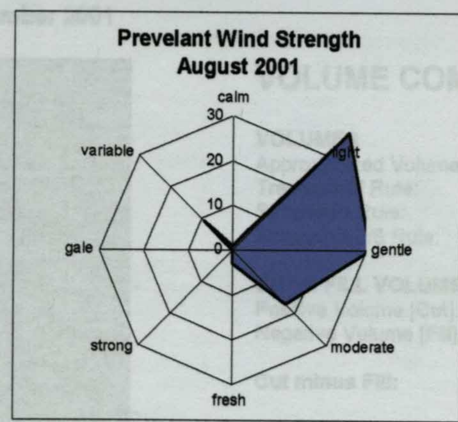
VOLUME COMPUTATIONS (m^3)

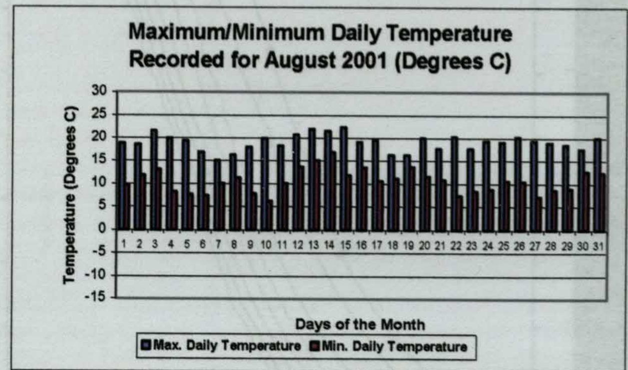
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**699267.434**
Simpson's Rule:	**699370.961**
Simpson's 3/8 Rule:	**699401.128**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**699526.003**
Negative Volume [Fill]:	**257.725**
Cut minus Fill:	**699268.278**

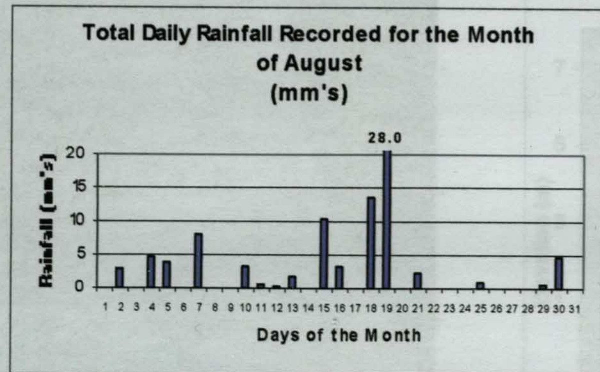


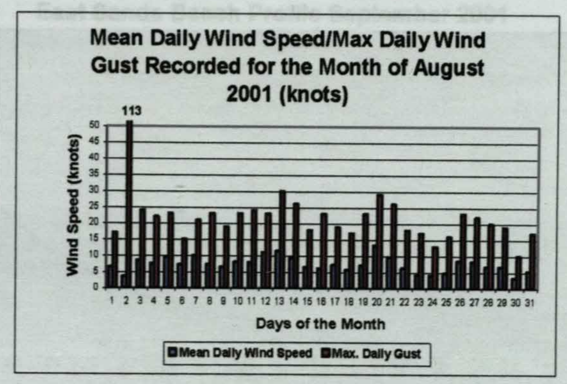
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











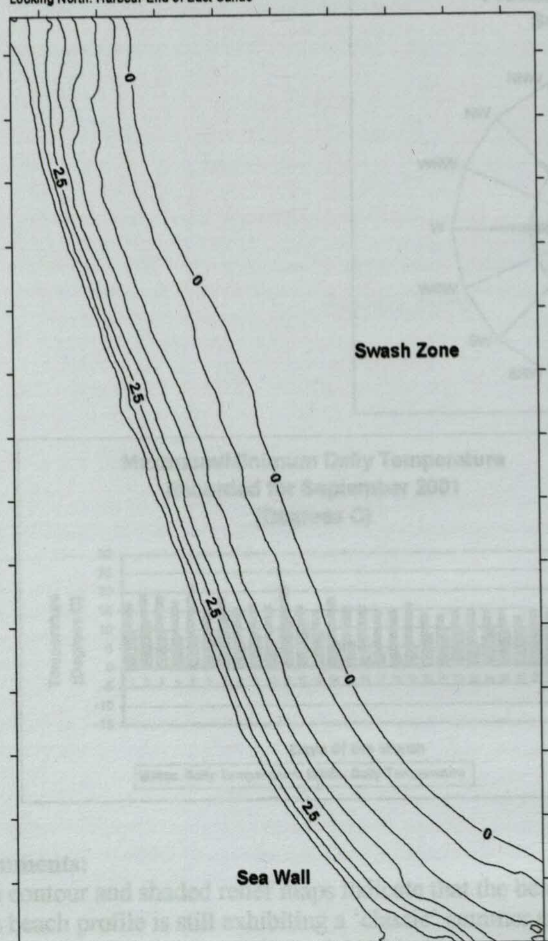
Comments:

The contour and shaded relief maps indicate that the beach face rises 2m above sea level in the swash zone, through a distinct ridge of 4.5m up to 7m above sea level at the sea wall.
This beach profile is almost a 'classic' summer profile shape – wide berm against the sea wall, smooth, sloping profile, wide back beach and a steep foreshore.
The volume of sand is rounded up, and estimated at 699268m³ in volume. A massive increase from July, indicative of a highly 'constructive' period.
The temperature ranged from above 5°C to roughly 24°C.
Again, overall there was low rainfall throughout the entire month, ranging from 0mm to 28mm falling in any one day, 28mm being almost a freak volume.
The wind direction was primarily westerly, but with an occurrence north westerly, south westerly and easterly directions at times.
The wind strength varied from light, through gentle to moderate, bordering on fresh on occasion, and being roughly between 1-21 knots in speed.
The Beaufort Force would have been between 1 and 5, meaning incidence of moderate to small waves, large wavelets and crests.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

SEPTEMBER 2001

CONTOUR MAP 19th September 2001
Looking North: Harbour End of East Sands



Looking South: Kinkell Braes End of East Sands

SHADED RELIEF MAP 19th September 2001

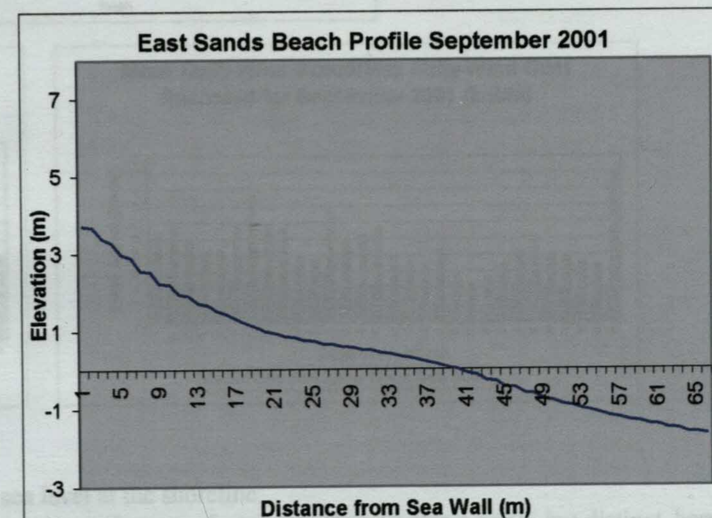
VOLUME COMPUTATIONS (m³)

VOLUMES

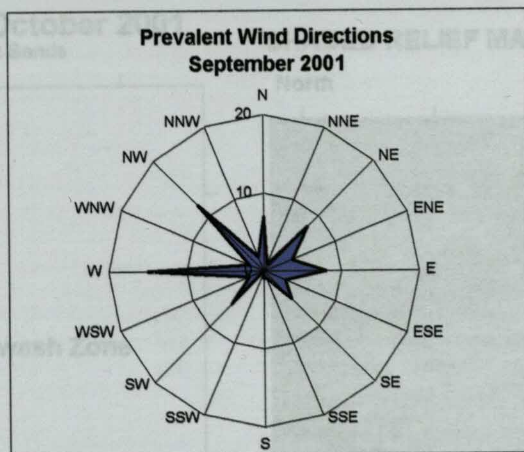
Approximated Volume by	
Trapezoidal Rule:	699267.434
Simpson's Rule:	699370.961
Simpson's 3/8 Rule:	699401.128

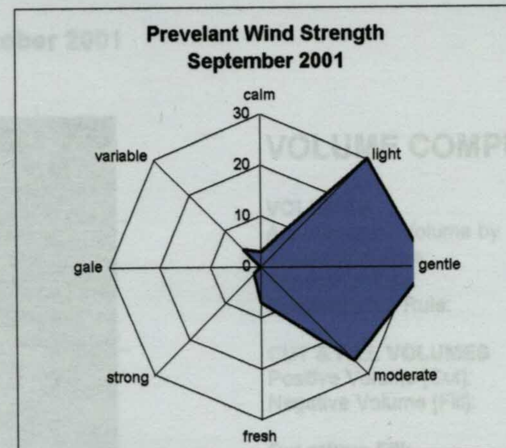
CUT & FILL VOLUMES

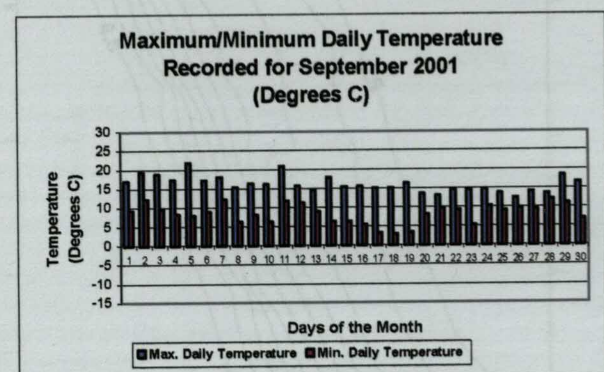
Positive Volume [Cut]:	687513.229
Negative Volume [Fill]:	257.725
Cut minus Fill:	**44722.949**

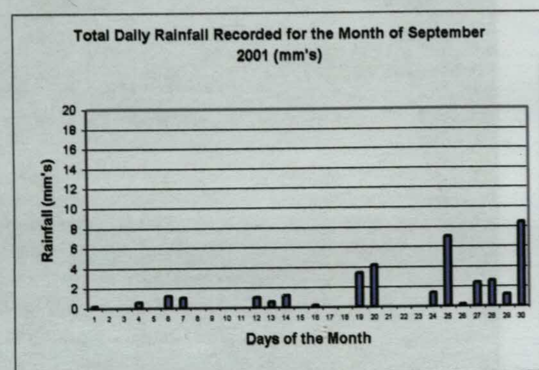


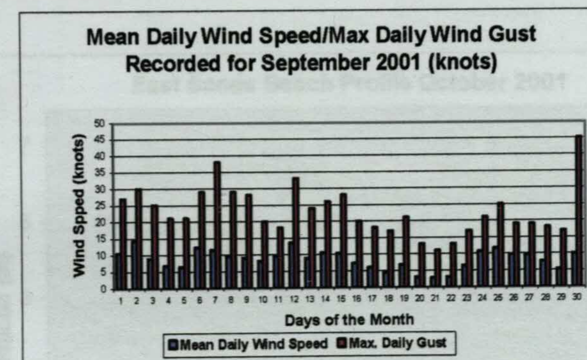
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

The contour and shaded relief maps indicate that the beach face rises to 3.5m at the sea wall sloping to 0m above sea level at the shoreline.

The beach profile is still exhibiting a 'classic' summer profile shape, sloping smoothly to the offshore zone, from a steep and narrow foreshore. There is also a small, but distinct, berm pres

The volume of sand is an estimated 64723m³ in volume, although a decrease on last month still high enough to indicate a 'construcitive' period.

The temperature ranged from above 3°C to roughly 23°C.

Again, overall there was relatively low rainfall throughout the entire month, ranging from 0mm to 9mm falling in any one day.

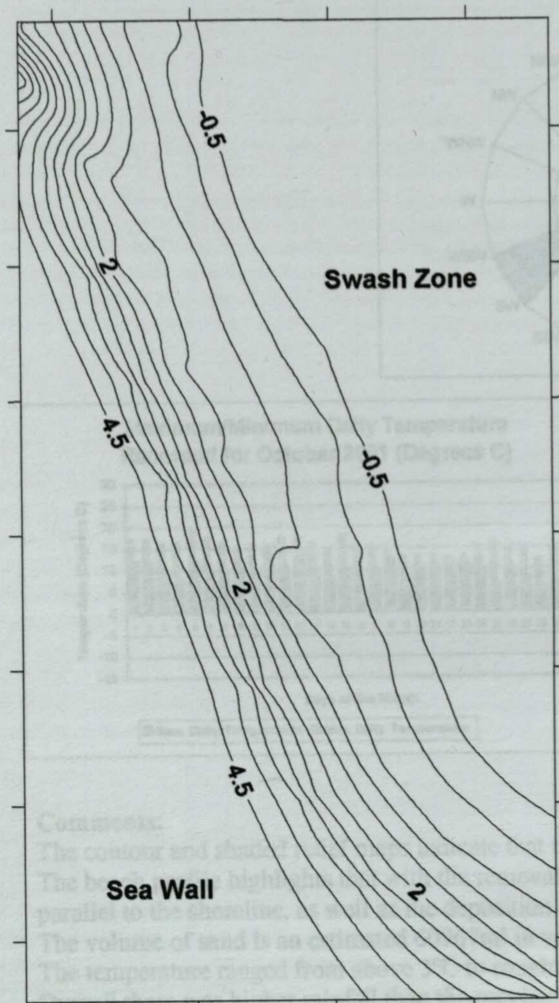
The wind direction was primarily north westerly and westerly, but with an occurrence north easterly, easterly and south easterly directions at times.

The wind strength varied from light, through gentle to moderate, bordering on strong on occasion, and ranging roughly between 1-47 knots in speed.

The Beaufort Force would have been between 1 and 9, meaning incidence of high and moderate to small waves, large wavelets and crests and sea spray.

OCTOBER 2001

CONTOUR MAP 19th October 2001
Looking North: Harbour End of East Sands

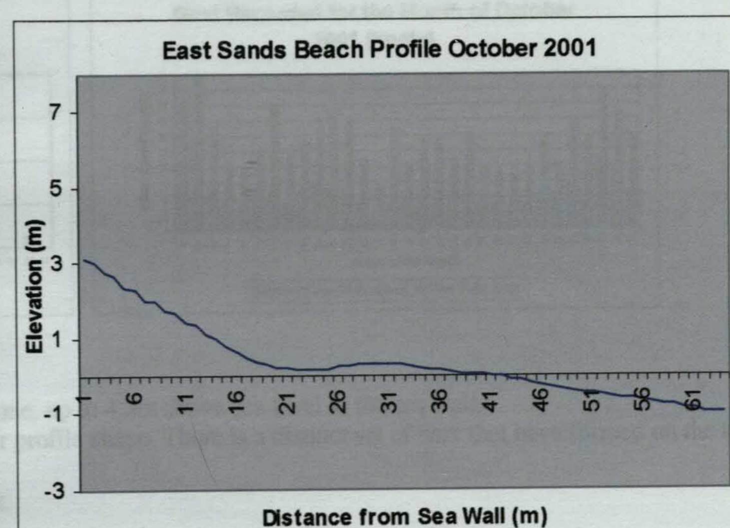


Looking South: Harbour End of East Sands

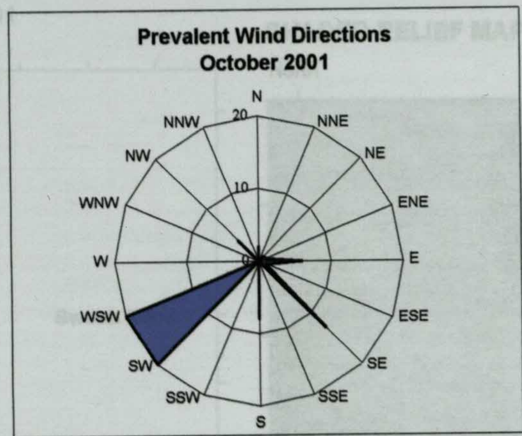
SHADED RELIEF MAP 19th October 2001

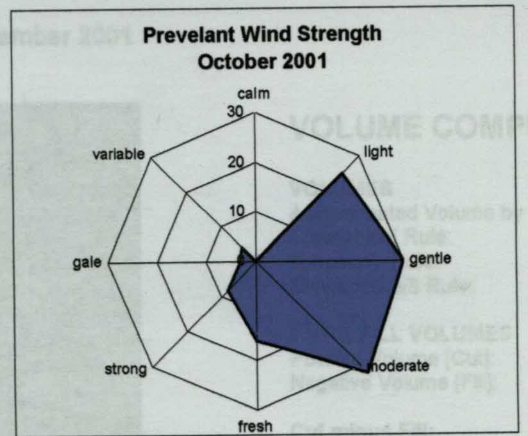
VOLUME COMPUTATIONS (m^3)

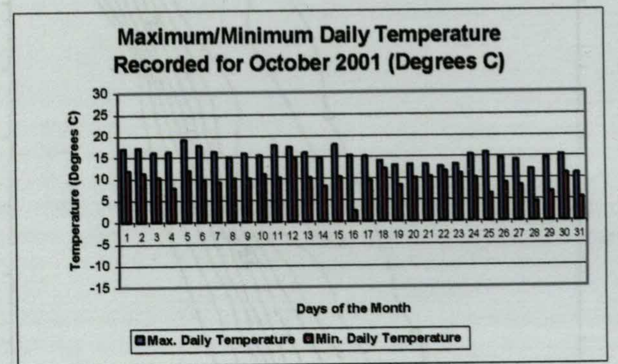
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**60967.063**
Simpson's Rule:	**61025.077**
Simpson's 3/8 Rule:	**61067.966**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**97959.172**
Negative Volume [Fill]:	**36992.108**
Cut minus Fill:	**60967.063**

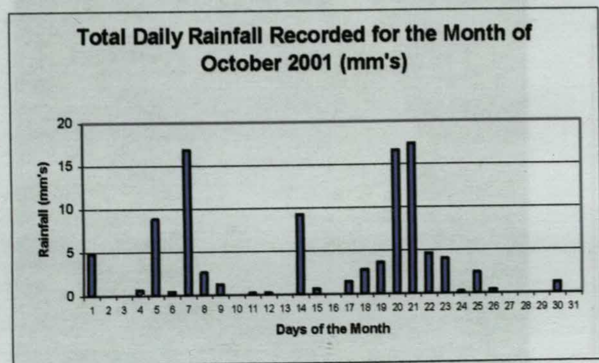


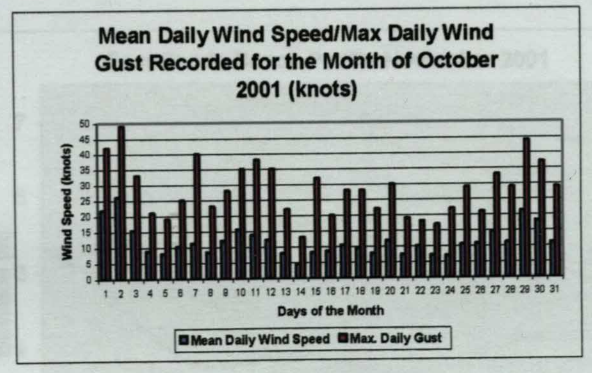
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

The contour and shaded relief maps indicate that the beach face rises –0.5m above sea level in the swash zone, up to 4.5m above sea level at the sea wall.

The beach profile highlights that with the removal of the berm, the profile is shifting towards a more winter profile shape. There is a distinct set of bars that have formed on the beach parallel to the shoreline, as well as the deposition of a bar at the low tide level.

The volume of sand is an estimated 60967m³ in volume, still maintaining volume in this constructive phase.

The temperature ranged from above 3°C to roughly 17°C.

Overall there was higher rainfall than the previous month, ranging from 0-1mm to 17mm falling in any one day, and 22 days experiencing rainfall.

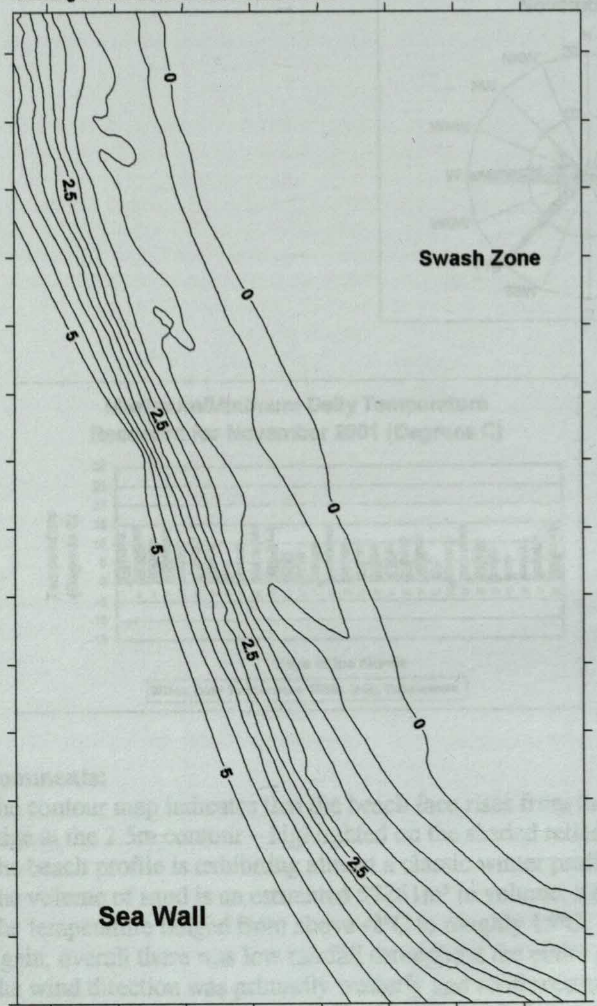
The wind direction was primarily southwesterly and west south westerly, but with an occurrence easterly directions at times.

The wind strength varied from light, through gentle to moderate, but with an incidence of strong on occasion, and being roughly between 1-47 knots in speed.

The Beaufort Force would have been between 1 and 9, meaning incidence of high and moderate to small waves, large wavelets and crests, and sea spray.

NOVEMBER 2001

CONTOUR MAP 18th November 2001



SHADED RELIEF MAP 18th November 2001

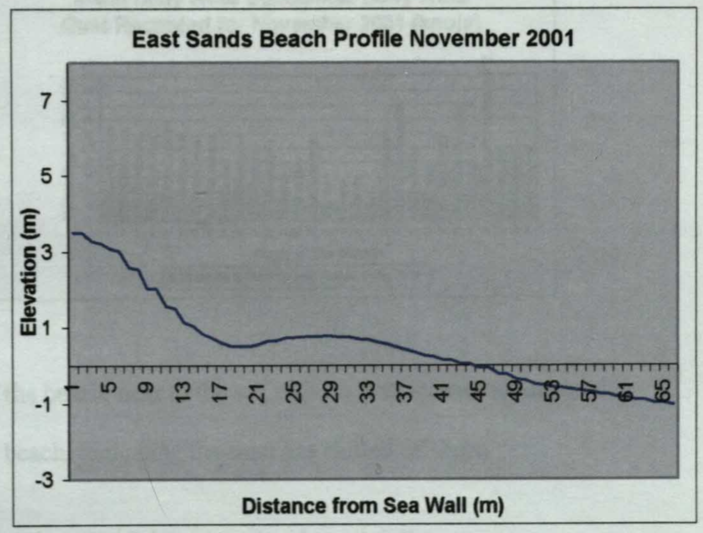
VOLUME COMPUTATIONS (m³)

VOLUMES

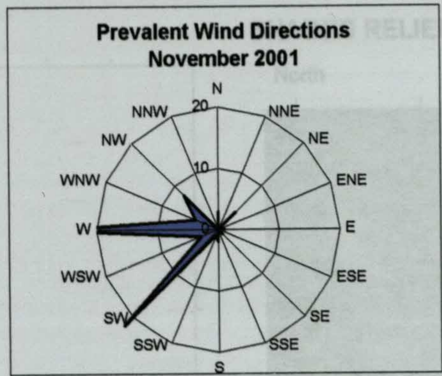
Approximated Volume by	
Trapezoidal Rule:	57260.615
Simpson's Rule:	57338.212
Simpson's 3/8 Rule:	57362.886

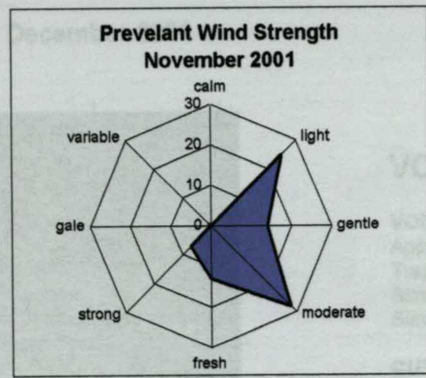
CUT & FILL VOLUMES

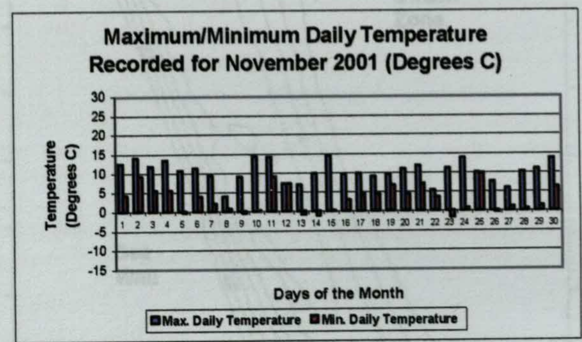
Positive Volume [Cut]:	98309.871
Negative Volume [Fill]:	41049.256
Cut minus Fill:	**57260.615**

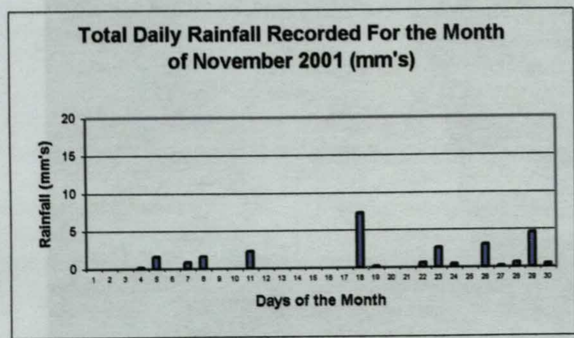


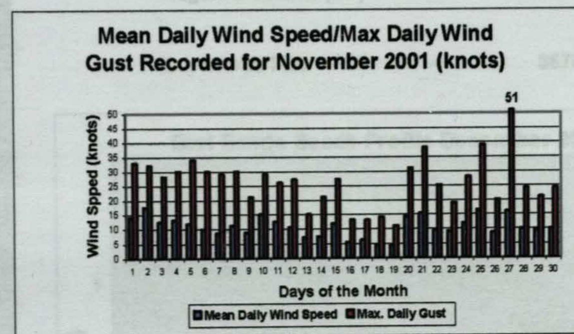
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

The contour map indicates that the beach face rises from 0m – 5m above sea level. It has a distinct ridge at the top of the beach, near to the sea wall, as well as another distinctive ridge at the 2.5m contour – highlighted on the shaded relied map.

The beach profile is exhibiting almost a classic winter profile shape – almost no berm in evidence and a narrow back beach, indicating the sand has shifted offshore.

The volume of sand is an estimated 57261m³ in volume, a decrease from last month.

The temperature ranged from above -2°C to roughly 15°C.

Again, overall there was low rainfall throughout the entire month, ranging from 0mm to 7mm falling in any one day, with only 15 days experiencing rainfall.

The wind direction was primarily westerly and southwesterly, but with an occurrence northwesterly at times.

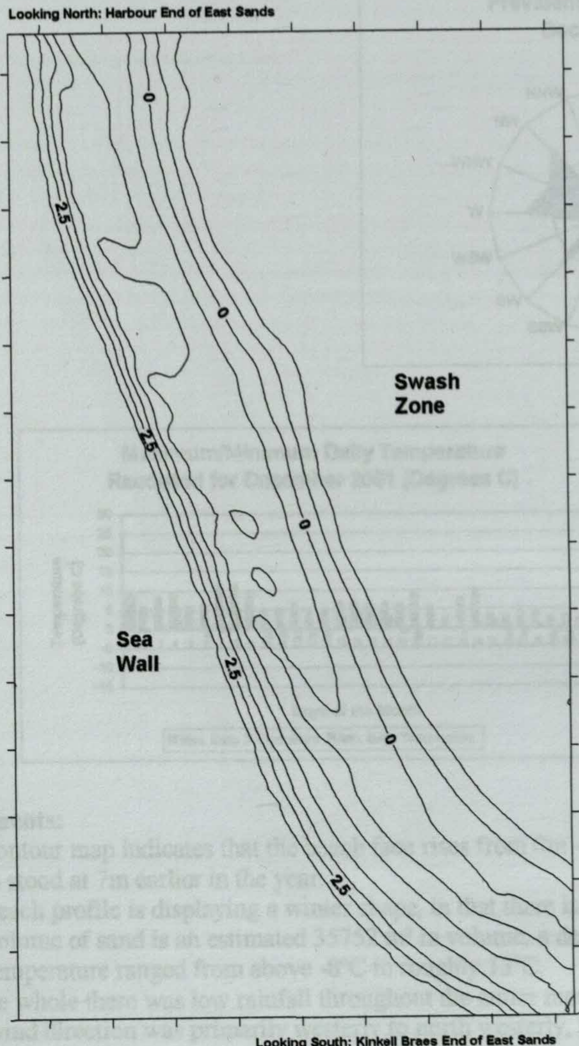
The wind strength varied from light, through gentle but more moderate, bordering on strong on occasion, and being roughly between 1-51 knots in speed.

The Beaufort Force would have been between 1 and 5, meaning incidence of high and moderate to small waves, large wavelets and crests, with generous sea spray.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

DECEMBER 2001

CONTOUR MAP 17th December 2002



SHADED RELIEF MAP 17th December 2001

VOLUME COMPUTATIONS (m³)

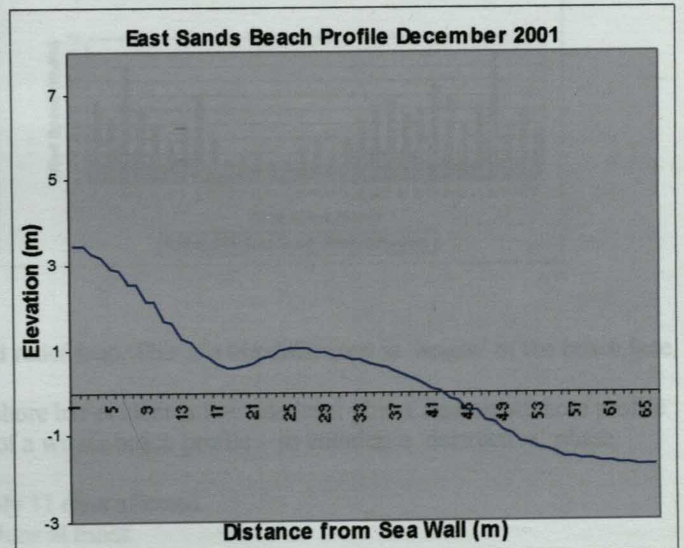
VOLUMES

Approximated Volume by	
Trapezoidal Rule:	**35752.399**
Simpson's Rule:	**35836.731**
Simpson's 3/8 Rule:	**35859.846**

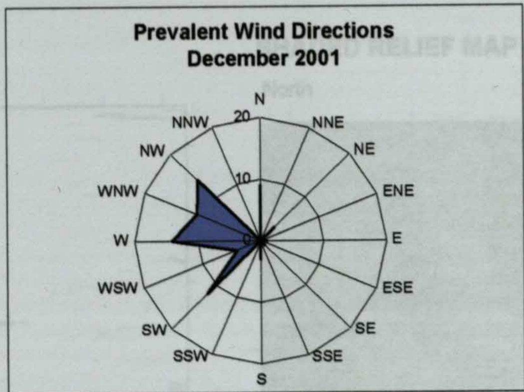
CUT & FILL VOLUMES

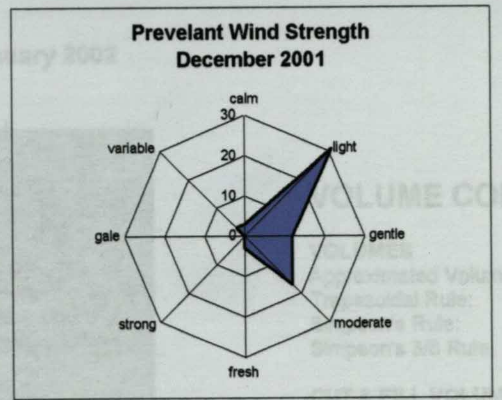
Positive Volume [Cut]:	**98352.395**
Negative Volume [Fill]:	**62599.997**

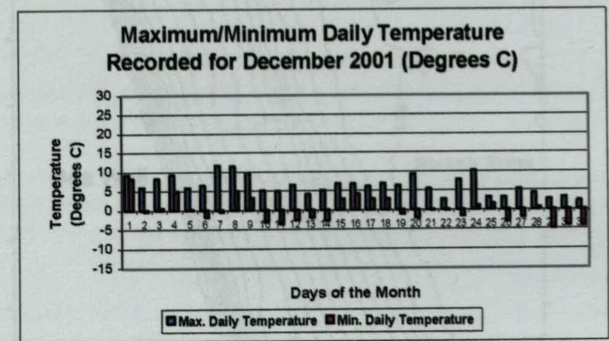
Cut minus Fill:	**35752.399**

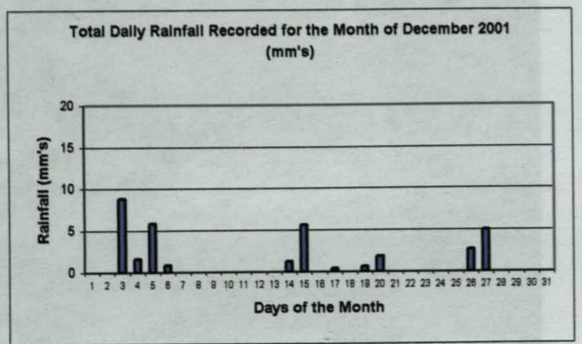


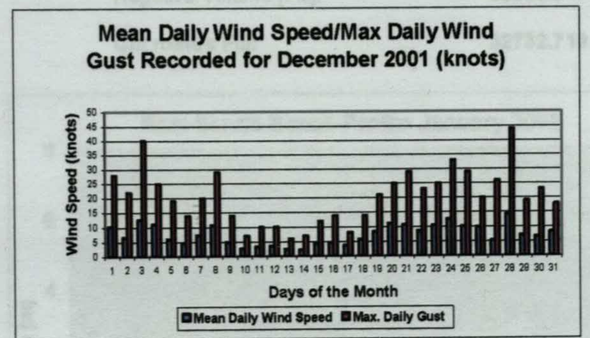
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS







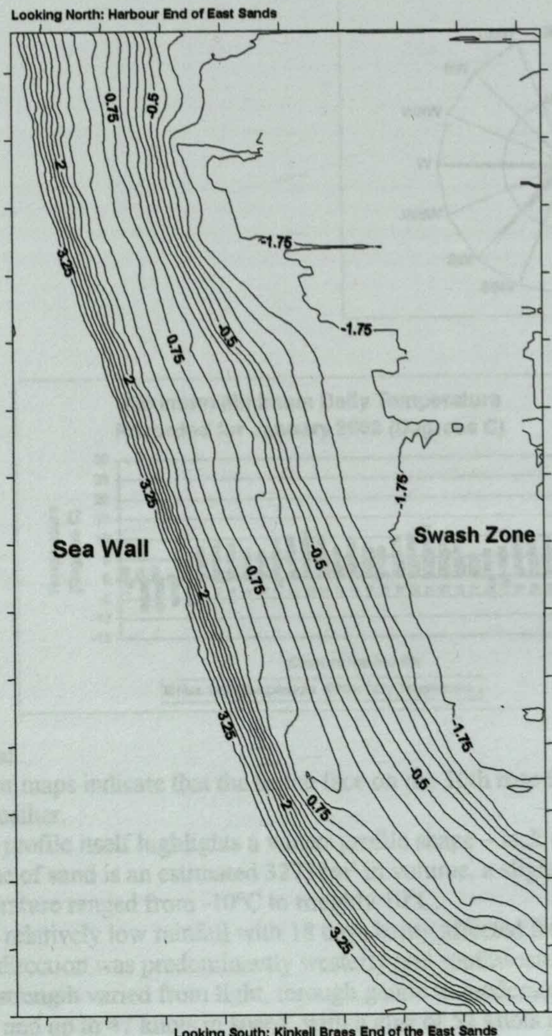




Comments:
The contour map indicates that the beach face rises from 0m - 2.5m, with two very distinct ridges highlighted on the shaded relief map. This is a big difference in 'height' of the beach face, which stood at 7m earlier in the year.
The beach profile is displaying a winter shape, in that there is no real berm present, a narrow back beach, as well as a longshore bar evident at low tide level plus a smooth offshore profile
The volume of sand is an estimated 35752 m^3 in volume, a decrease from last month, but concurrent with the construction of a winter beach profile – so entering a 'destructive' phase.
The temperature ranged from above -8°C to roughly 13°C.
On the whole there was low rainfall throughout the entire month, ranging from 0mm to 9mm falling in any one day, and only 11 days affected.
The wind direction was primarily westerly to north westerly, but with frequent bouts of south westerly and northerly directions at times.
The wind strength varied from light, through gentle to moderate, only slightly bordering on fresh on occasion, so being roughly between 1-21 knots in speed.
The Beaufort Force would have been between 1 and 5, meaning incidence of moderate to small waves, large wavelets and crests, exhibiting 'white horses'.

JANUARY 2002

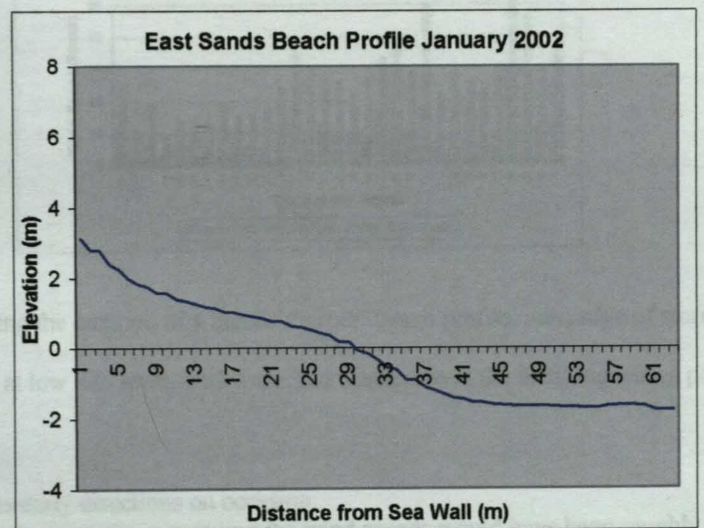
CONTOUR MAP 16th January 2002



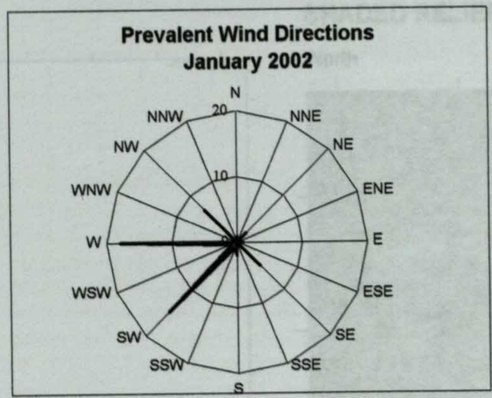
SHADED RELIEF MAP 6: 16th January 2002

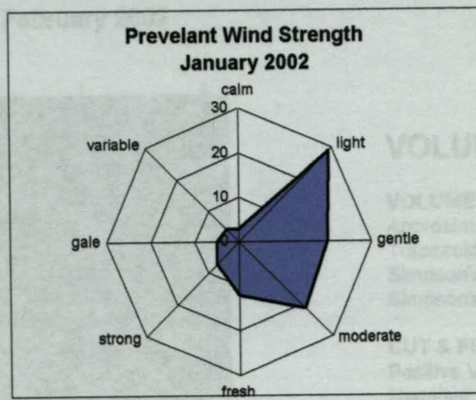
VOLUME COMPUTATIONS (m^3)

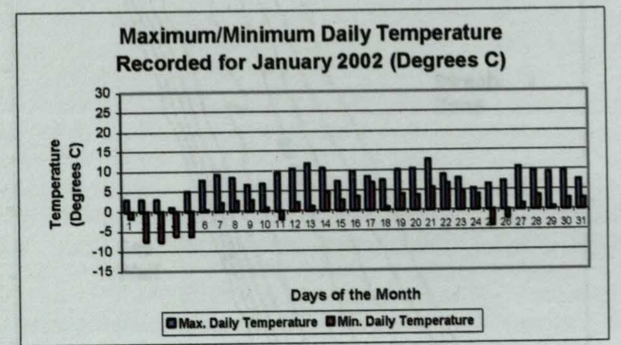
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	32732.719
Simpson's Rule:	32817.268
Simpson's 3/8 Rule:	32832.502
CUT & FILL VOLUMES	
Positive Volume [Cut]:	96618.066
Negative Volume [Fill]:	63885.347
Cut minus Fill:	32732.719

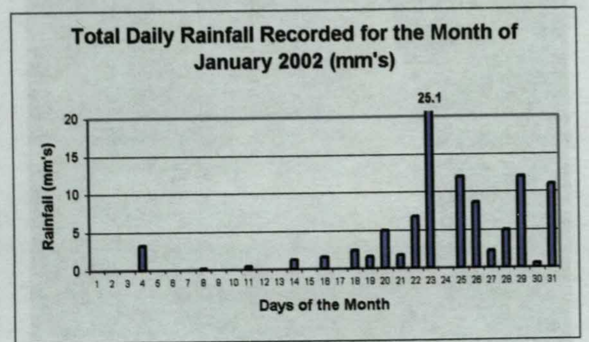


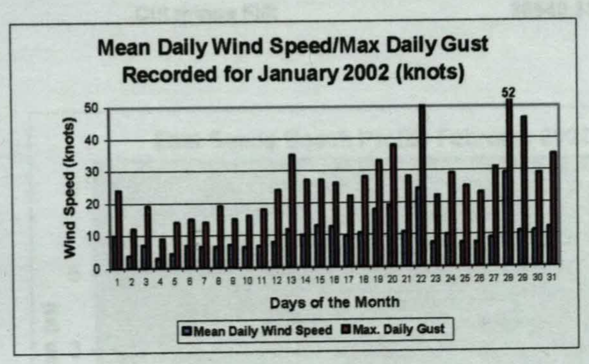
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

The contour maps indicate that the beach face on the 16th rose from -1.75m in the swash zone, to 3.25 at the sea wall, indicating the creation of a much 'sharper' beach profile, indicative of storm 'winter' weather.

The beach profile itself highlights a winter profile shape – lack of berm, severe reduction in sediment volumes, longshore bar at low tide level, with a marked beach step at the breaking waves poi

The volume of sand is an estimated 32733m³ in volume, a slight decrease from last month.

The temperature ranged from -10°C to roughly 10°C.

There was relatively low rainfall with 18 days being affected from as little as 1mm a day to anything up to 25mm a day.

The wind direction was predominantly westerly and southwesterly, but with small incidence of both northwesterly and southeasterly directions on occasion.

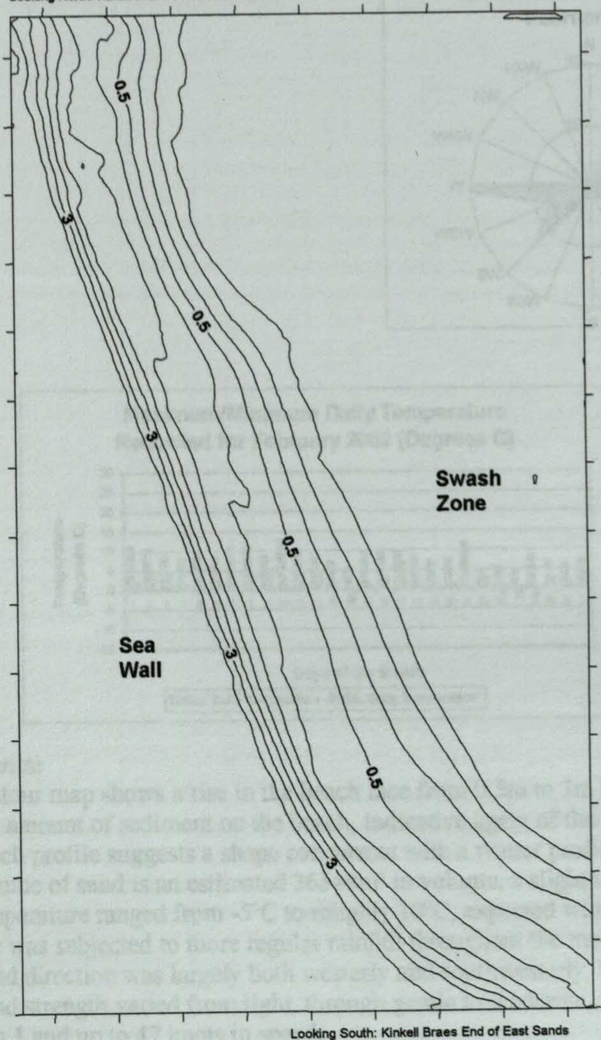
The wind strength varied from light, through gentle to moderate, with distinct periods of both strong and gale strengths on notable occasions, meaning the wind speeds would have been roughly between 1 and up to 47 knots in speed, with a gust of 52 knots noted.

The Beaufort Force would have been between 1 and 9, meaning frequency of high waves and dense foam, as well as moderate to small waves, large wavelets and crests, exhibiting 'white horses' ; visibility reducing sea spray.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

FEBRUARY 2002

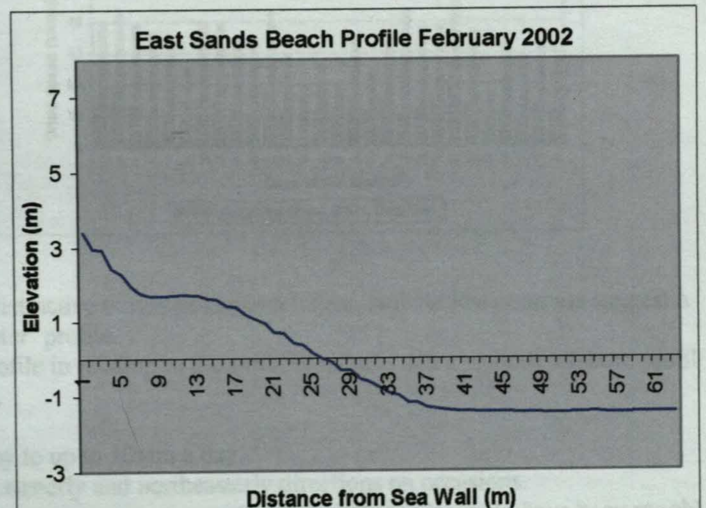
CONTOUR MAP 2nd February 2002



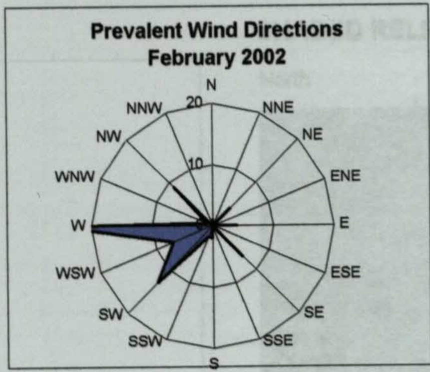
SHADED RELIEF MAP 2nd February 2002

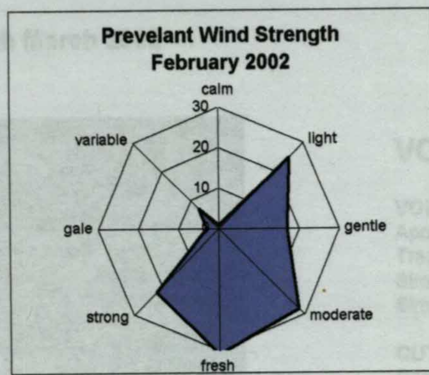
VOLUME COMPUTATIONS (m³)

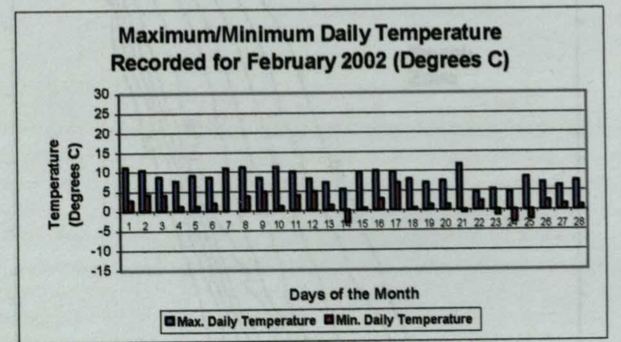
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**36540.333**
Simpson's Rule:	**36619.866**
Simpson's 3/8 Rule:	**36655.608**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**100294.129**
Negative Volume [Fill]:	**63753.796**
Cut minus Fill:	**36540.333**

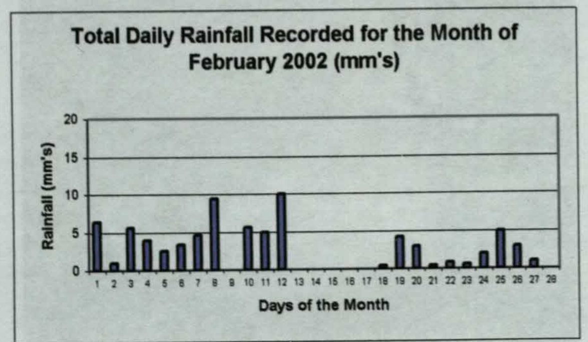


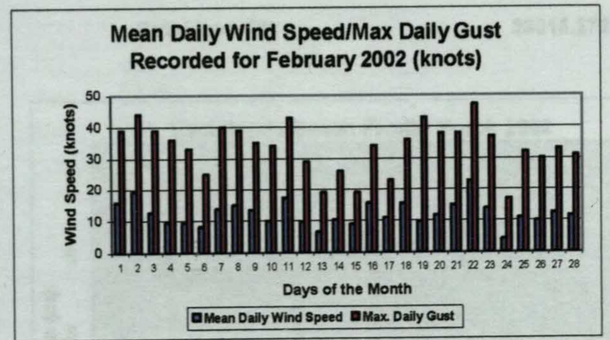
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

The contour map shows a rise in the beach face from 0.5m to 3m by the sea wall. The shaded relief map also highlights two distinctive berms on the beach face, and the low contours suggest a reduced amount of sediment on the beach, indicative again of the beach adjusting to prevalent conditions and adopting a 'winter' profile.

The beach profile suggests a shape concurrent with a winter profile – again lack of a berm, a narrow back beach, a smaller profile in relation to the summer months and a smooth offshore profil

The volume of sand is an estimated 36540m³ in volume, a slight increase from January, indicating calmer weather conditions.

The temperature ranged from -5°C to roughly 10°C, expected winter temperatures for eastern Scotland.

The site was subjected to more regular rainfall throughout the month with 21 days being affected from as little as 2-3mm a day to up to 10mm a day.

The wind direction was largely both westerly and southwesterly, but with notable occurrence of northwesterly, southeasterly, easterly and northeasterly directions on occasions.

The wind strength varied from light, through gentle to moderate, with distinct periods of both fresh, strong and gale strengths some occasions, meaning the wind speeds would have been roughl between 1 and up to 47 knots in speed.

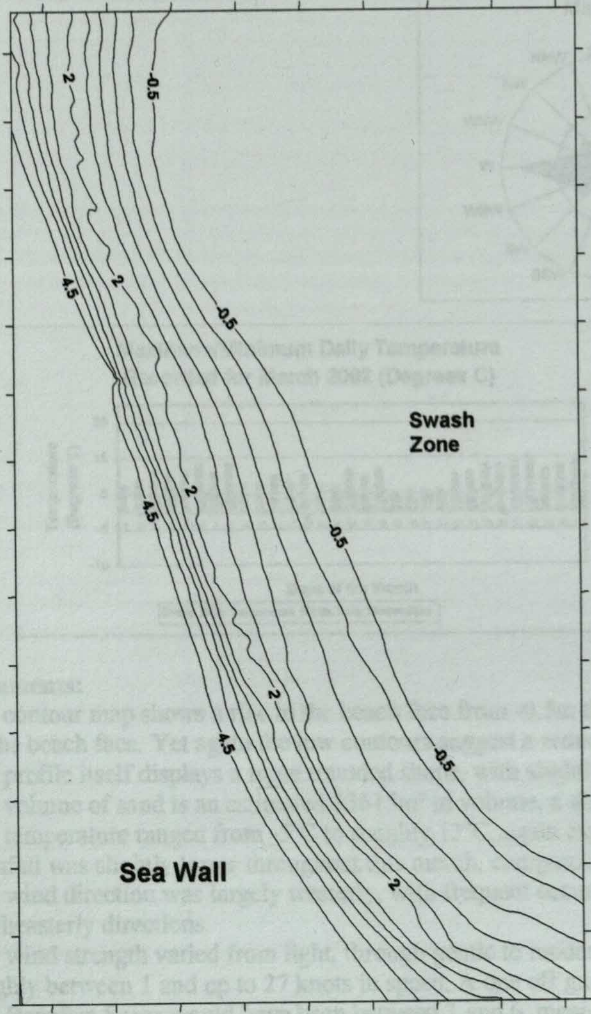
The Beaufort Force would have been between 1 and 9, meaning regularity again of high waves and dense foam, as well as moderate to small waves, large wavelets and crests, exhibiting 'white horses' and visibility reducing sea spray.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

MARCH 2002

CONTOUR MAP 11th March 2002

Looking North: Harbour End of East Sands



Looking South: Kinkell Bares End of East Sands

SHADED RELIEF MAP 11th March 2002

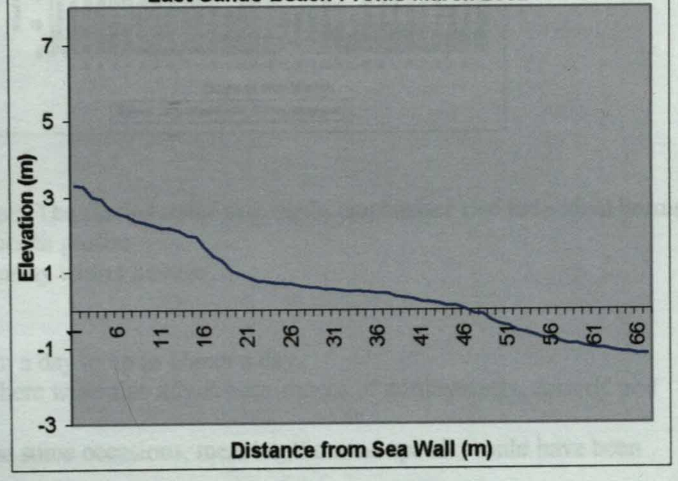
North

South

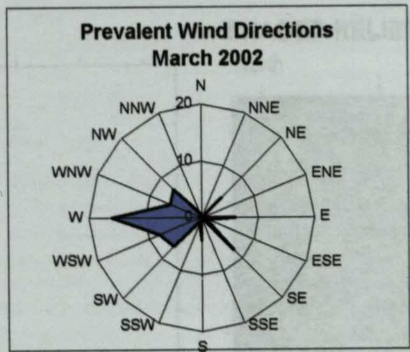
VOLUME COMPUTATIONS (m³)

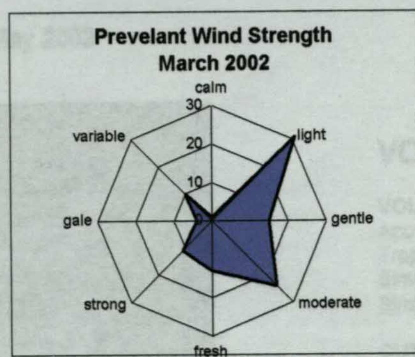
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	33615.272
Simpson's Rule:	33673.049
Simpson's 3/8 Rule:	33732.433
CUT & FILL VOLUMES	
Positive Volume [Cut]:	100353.751
Negative Volume [Fill]:	66738.479
Cut minus Fill:	33615.272

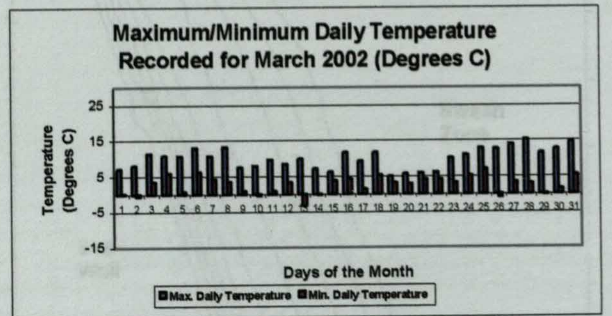
East Sands Beach Profile March 2002

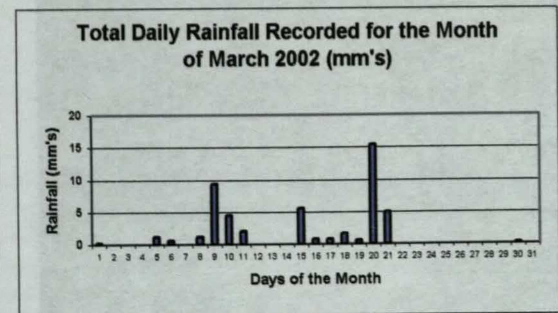


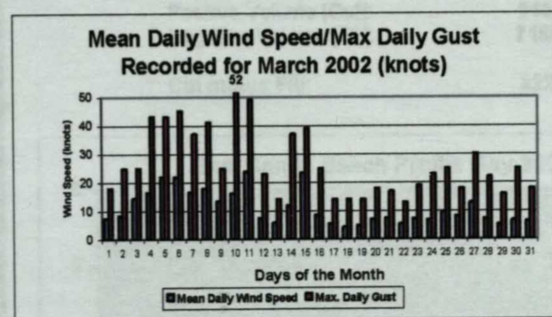
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











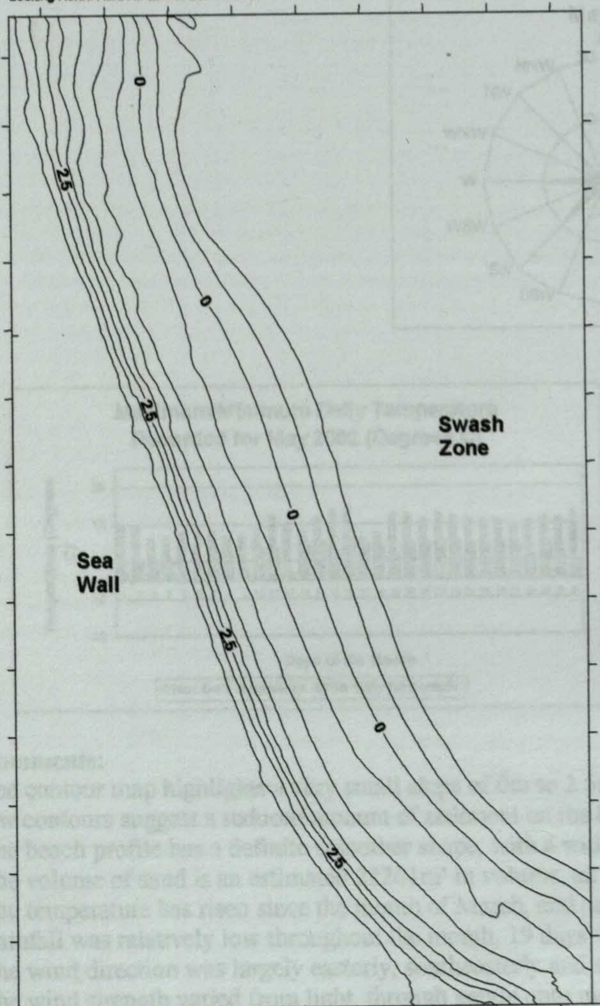
Comments:
The contour map shows a rise in the beach face from -0.5m through distinct ridges at 2m terminating at 4.5m at the sea wall. The shaded relief map again emphasises two individual berms on the beach face. Yet again the low contours suggest a reduced amount of sediment on the beach, indication of a winter beach profile.
The profile itself displays a more rounded shape, with slightly increases volumes, indicating a recovery period after the stormy winter months.
The volume of sand is an estimated 33615m³ in volume, a slight decrease from last month.
The temperature ranged from -5°C to roughly 13°C, again expected winter temperatures for the eastern coast of Scotland.
Rainfall was slightly lower throughout this month, compared with last, as only 16 days were affected from as little as 1mm a day to up to 16mm a day.
The wind direction was largely westerly, with frequent occurrences of both northwesterly and southwesterly directions. There were also minor occurrences of northeasterly, easterly and southeasterly directions.
The wind strength varied from light, through gentle to moderate, with distinct periods of both fresh and strong strengths on some occasions, meaning the wind speeds would have been roughly between 1 and up to 27 knots in speed. A one off gust of 52 knots was noted.
The Beaufort Force would have been between 1 and 6, meaning occurrence of large and moderate to small waves, large wavelets and crests, exhibiting 'white horses', with the likelihood of sea spray.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

MAY 2002

CONTOUR MAP 25th May 2002

Looking North: Harbour End of East Sands



Looking South: Kinkell Braes End of Esat Sands

SHADED RELIEF MAP 25th May 2002

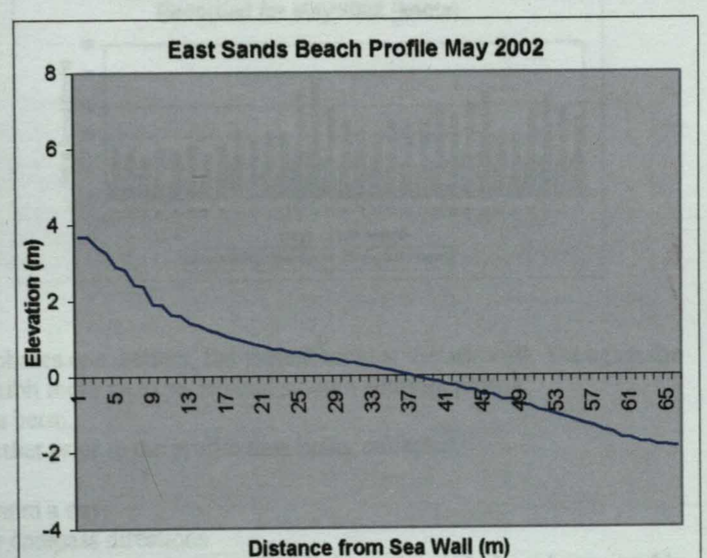
VOLUME COMPUTATIONS (m^3)

VOLUMES

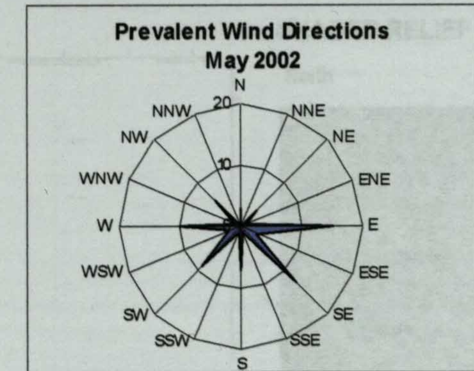
Approximated Volume by	
Trapezoidal Rule:	22261.260
Simpson's Rule:	22355.529
Simpson's 3/8 Rule:	22360.494

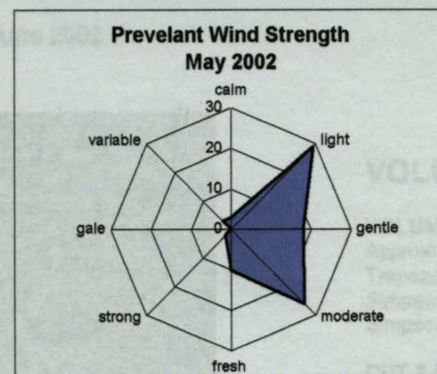
CUT & FILL VOLUMES

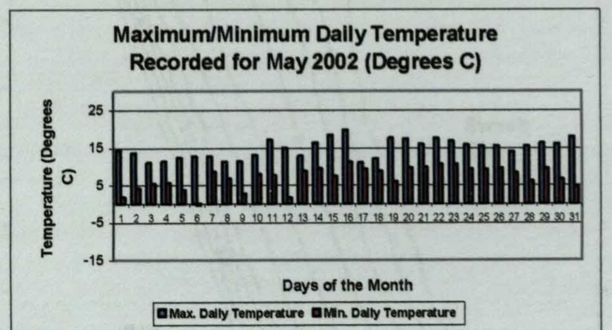
Positive Volume [Cut]:	94066.542
Negative Volume [Fill]:	71805.282
Cut minus Fill:	22261.260

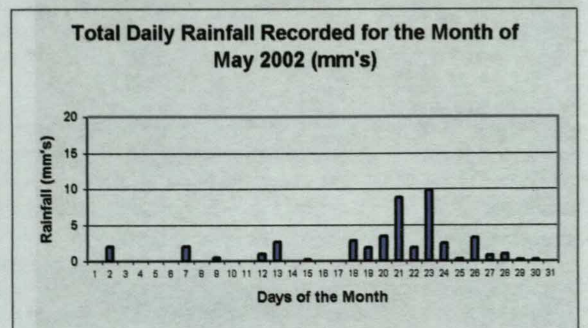


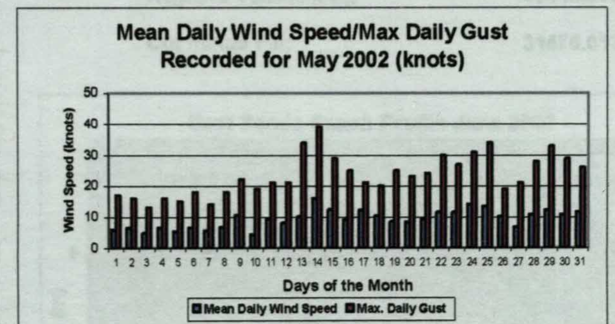
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

The contour map highlights a very small slope of 0m to 2.5m, terminating at the sea wall. The shaded relief map emphases one distinct, flat topped berm at the sea wall. Yet again the low contours suggest a reduced amount of sediment on the beach, indication still that the beach face is starting to exhibit more an expected and smooth summer profile.

The beach profile has a definite smoother shape, with a wider back beach and steep foreshore and the beginnings of a berm.

The volume of sand is an estimated 22261m³ in volume, an unusual decrease from last month, indicating stormy weather prior to the profile data being collected.

The temperature has risen since the month of March, and ranged from 1°C to around 17°C.

Rainfall was relatively low throughout the month, 19 days were affected from as little as 1mm a day to up to only 10mm a day.

The wind direction was largely easterly, southeasterly and southwesterly, with frequent occurrences of the rest of the compass directions.

The wind strength varied from light, through gentle onto moderate, with very slight periods of strong strengths on some occasions, meaning the wind speeds would have been roughly between 1 and 40 knots in speed.

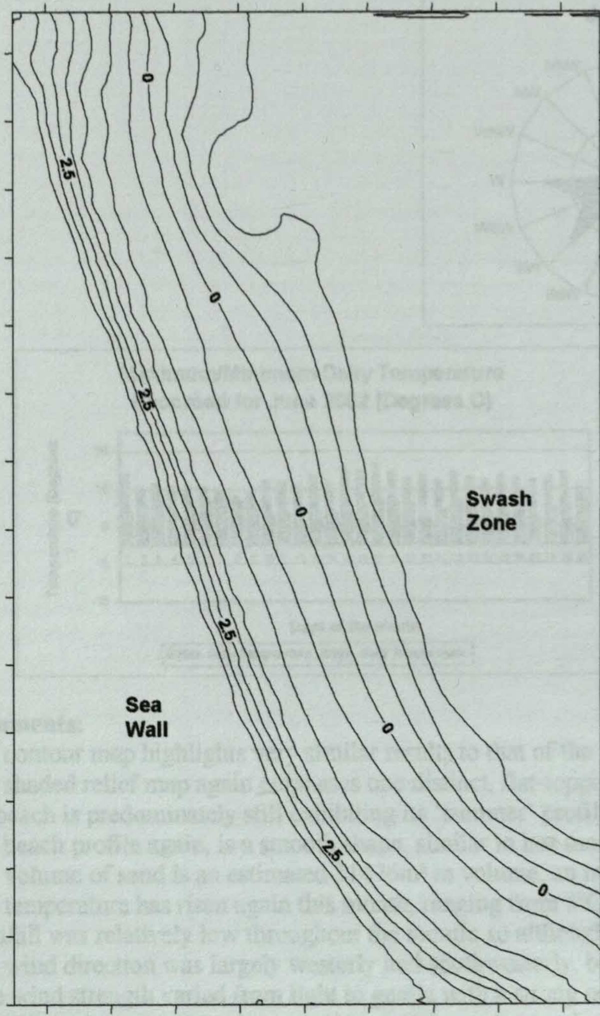
The Beaufort Force would have been between 1 and 8, meaning occurrence of moderate to small waves, large wavelets and crests, showing evidence of 'white horses', with the likelihood of sea spray and foam.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

JUNE 2002

CONTOUR MAP 25th June 2002

Looking North: Harbour End of East Sands



Looking South: Kinkell Braes End of East Sands

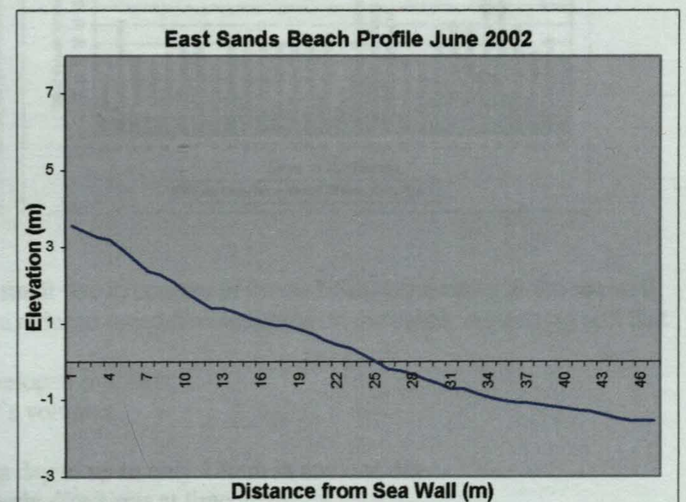
SHADED RELIEF MAP 25th June 2002

North

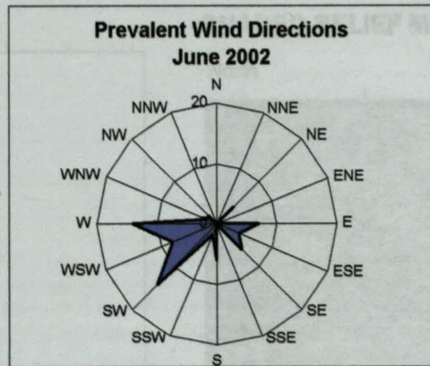
South

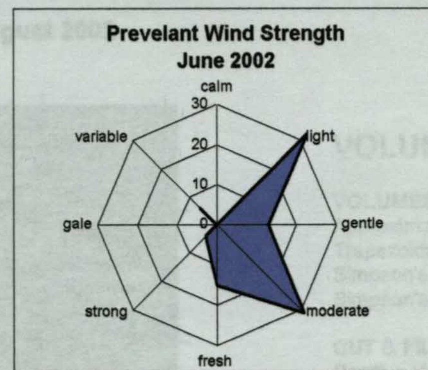
VOLUME COMPUTATIONS (m³)

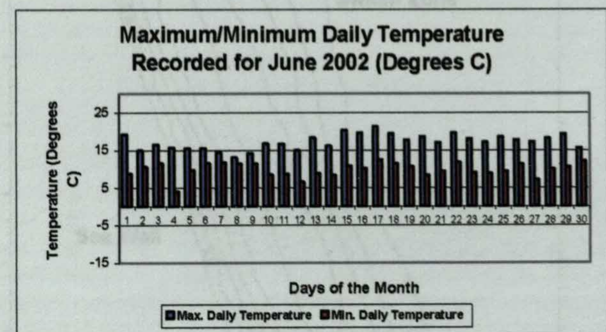
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**31476.013**
Simpson's Rule:	**31576.214**
Simpson's 3/8 Rule:	**31582.425**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**97922.822**
Negative Volume [Fill]:	**66446.809**
Cut minus Fill:	**31476.013**

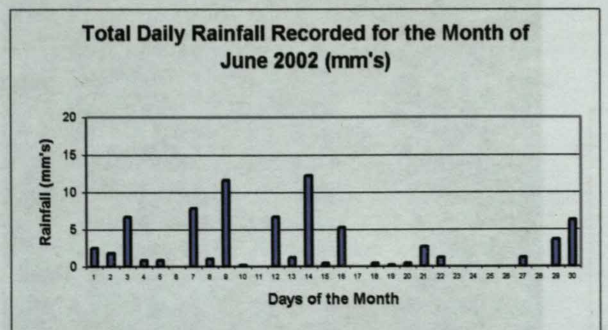


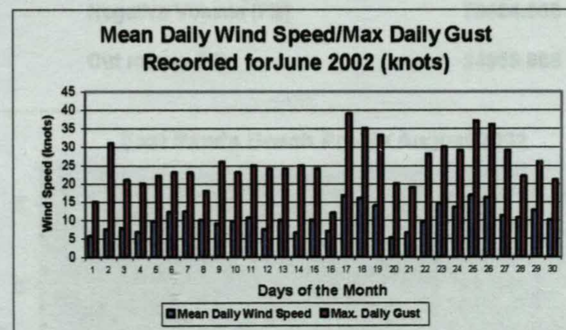
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











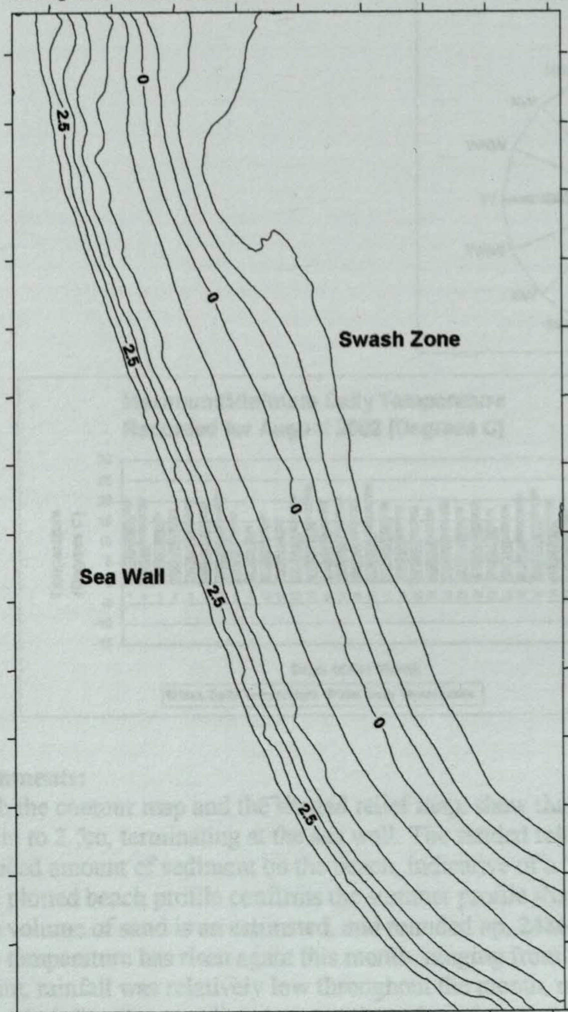
Comments:

The contour map highlights very similar results to that of the previous month of May, whereby the beach face exhibits a small rise in contour of 0m to 2.5m, terminating at the sea wall.
The shaded relief map again emphases one distinct, flat-topped berm at the sea wall. Yet again the low contours suggest a reduced amount of sediment on the beach, suggesting still that the beach is predominately still exhibiting its 'summer' profile.
The beach profile again, is a smooth shape, similar to last months. It has a wide, well developed back beach and well developed sandbars.
The volume of sand is an estimated 31476m³ in volume, an increase from last month, and more concurrent with last year's volumes.
The temperature has risen again this month, ranging from 5°C to around 23°C.
Rainfall was relatively low throughout the month; so although 21 days were affected, they received anything from 1mm a day to up to only 12mm in any one day.
The wind direction was largely westerly and southwesterly, but with a high incidence of both easterly and east south easterly directions at time.
The wind strength varied from light to gentle with a strong occurrence of moderate strengths, and a small incidence of strong strengths on some occasions, meaning the wind speeds would have been anything between 1 and 40 knots in speed.
The Beaufort Force would have been between 1 and 8, meaning there would have been a frequency of moderate to small waves, as well as large wavelets and crests, exhibiting evidence of 'white horses', with the probability of sea spray and dense sea foam.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

AUGUST 2002

CONTOUR MAP 22nd August 2002
Looking North: Harbour End of East Sands



Looking South: Kinkell Braes End of East Sands

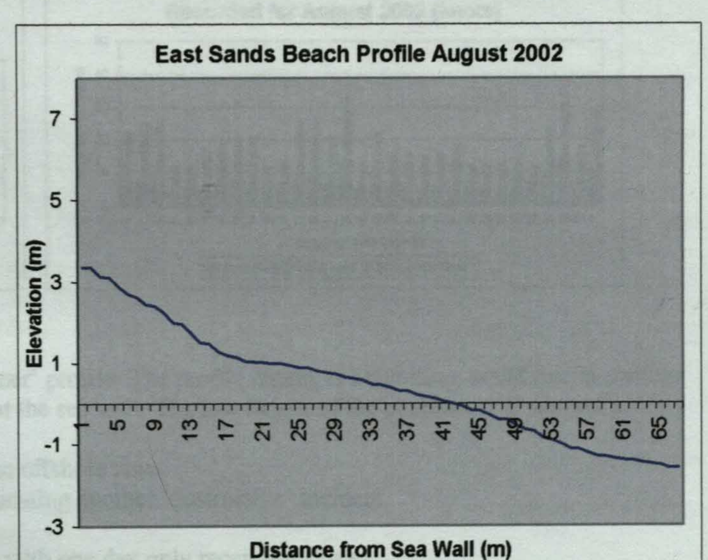
SHADED RELIEF MAP 22nd August 2002

North

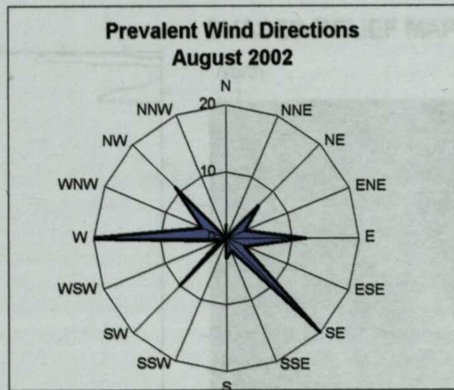
South

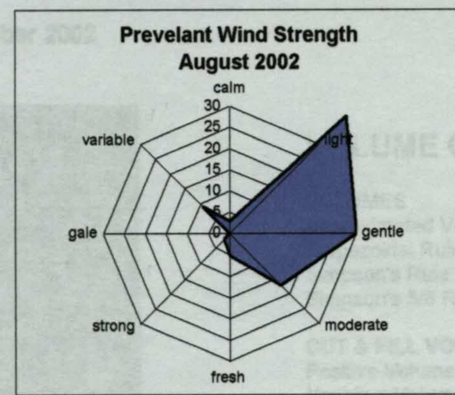
VOLUME COMPUTATIONS (m³)

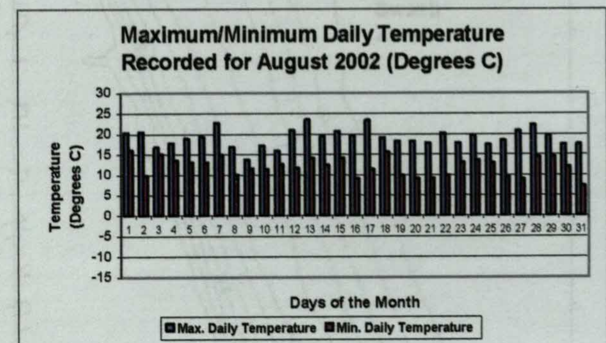
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**24859.888**
Simpson's Rule:	**24836.789**
Simpson's 3/8 Rule:	**24883.104**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**95284.443**
Negative Volume [Fill]:	**70424.555**
Cut minus Fill:	**24859.888**

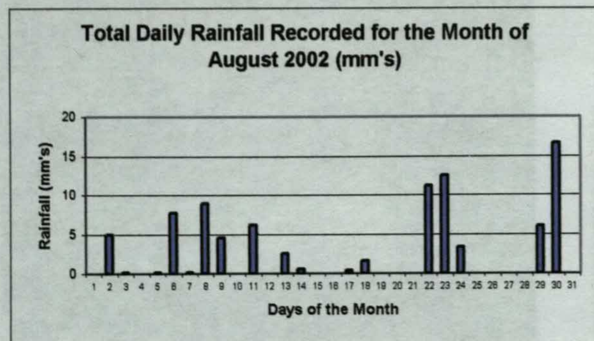


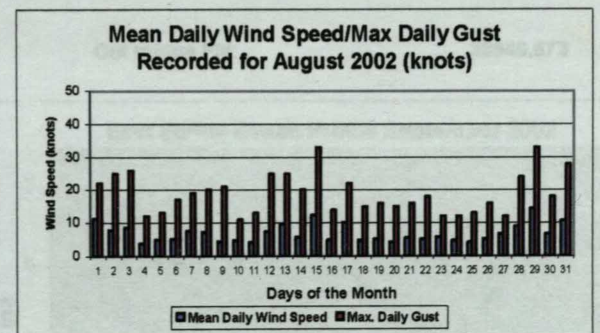
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

Both the contour map and the shaded relief map, show that the beach face of the study site is fully exhibiting its 'summer' profile. The profile, again, is exhibiting, small rise in contour of 0m to 2.5m, terminating at the sea wall. The shaded relief map once more illustrates one distinct, flat-topped berm at the sea wall. The low height of the contours still suggest a reduced amount of sediment on the beach, indicative of a 'summer' profile.

The plotted beach profile confirms the summer profile shape – with a more smooth topography, wide and sloping to the offshore zone.

The volume of sand is an estimated, and rounded up, 24860m³ in volume, another slight decrease from last month, indicating another 'destructive' incident.

The temperature has risen again this month, ranging from 7°C to around 25°C.

Again, rainfall was relatively low throughout the month, ranging from 0mm a day to up to only 12mm in any one day, with one day only receiving 17mm.

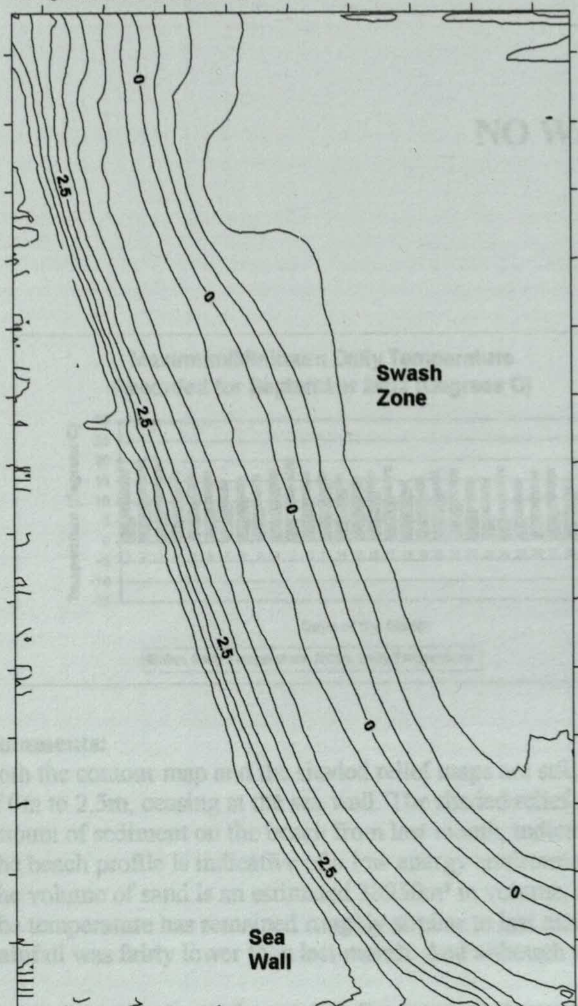
The wind direction was largely westerly and southeasterly, but with a high incidence of both easterly and westerly directions at times.

The wind strength varied from light to gentle with some occurrence of moderate strength, meaning the wind speeds would have been anything between 1 and 16 knots in speed.

The Beaufort Force would have been between 1 and 4, meaning there would have been incidences of small waves with frequent white horses, as well as large wavelets and crests.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

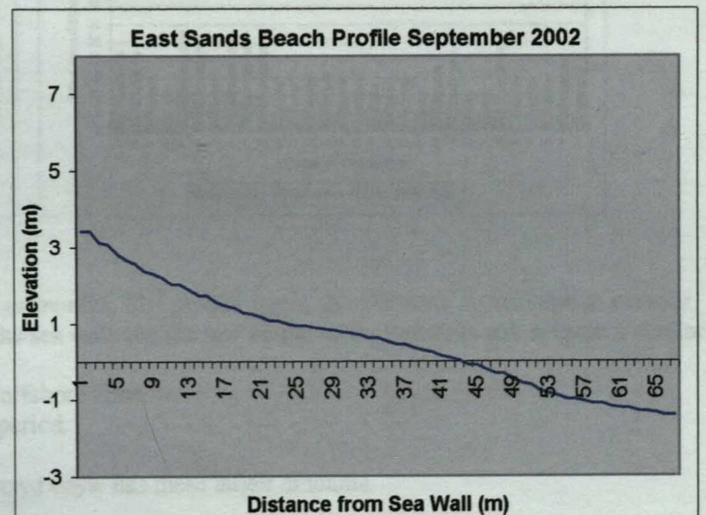
SEPTEMBER 2002



SHADED RELIEF MAP 25th September 2002

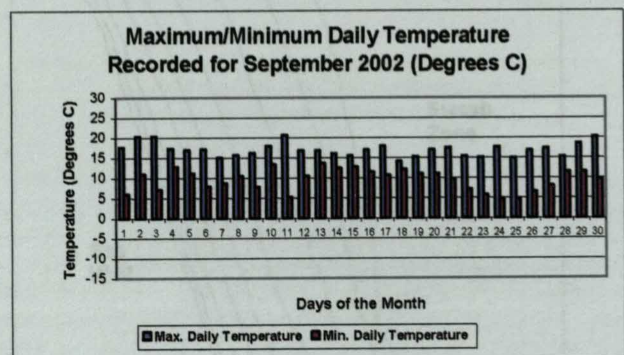
VOLUME COMPUTATIONS (m^3)

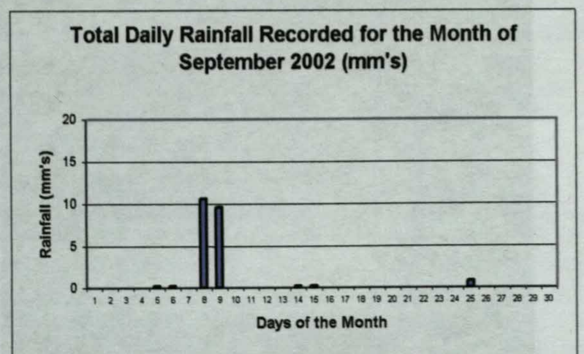
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	38949.573
Simpson's Rule:	39048.177
Simpson's 3/8 Rule:	39059.653
CUT & FILL VOLUMES	
Positive Volume [Cut]:	102459.188
Negative Volume [Fill]:	63509.615
Cut minus Fill:	38949.573

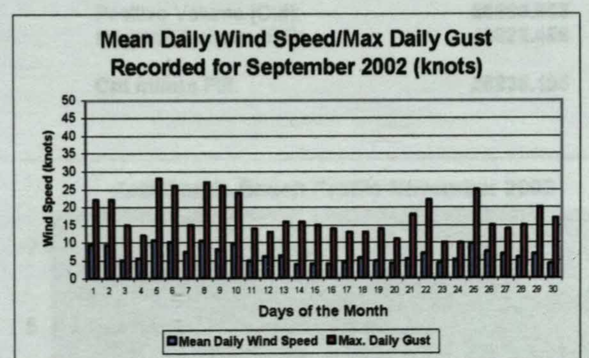


5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

NO WIND DIRECTION OR WIND STRENGTH DATA AVAILABLE







Comments:

Both the contour map and the shaded relief maps are still highlighting the same smooth profile shown over the last four months. The profile, again, is exhibiting a small rise in contour of 0m to 2.5m, ceasing at the sea wall. The shaded relief map once more illustrates one distinct, flat-topped berm at the sea wall and the low height of the contours still suggest a similar amount of sediment on the beach from last month, indicative of a 'summer' profile.

The beach profile is indicative of a low energy environment – smooth profile, wide back beach gently sloping to the offshore zone.

The volume of sand is an estimated 38950m³ in volume, a increase from August, and proof of a more 'constructive' period.

The temperature has remained roughly similar to last month, ranging from 6°C to around 23°C.

Rainfall was fairly lower than last month. And although ranging from 1mm to 11mm, only two days out of the 7 affected days, has these larger amounts.

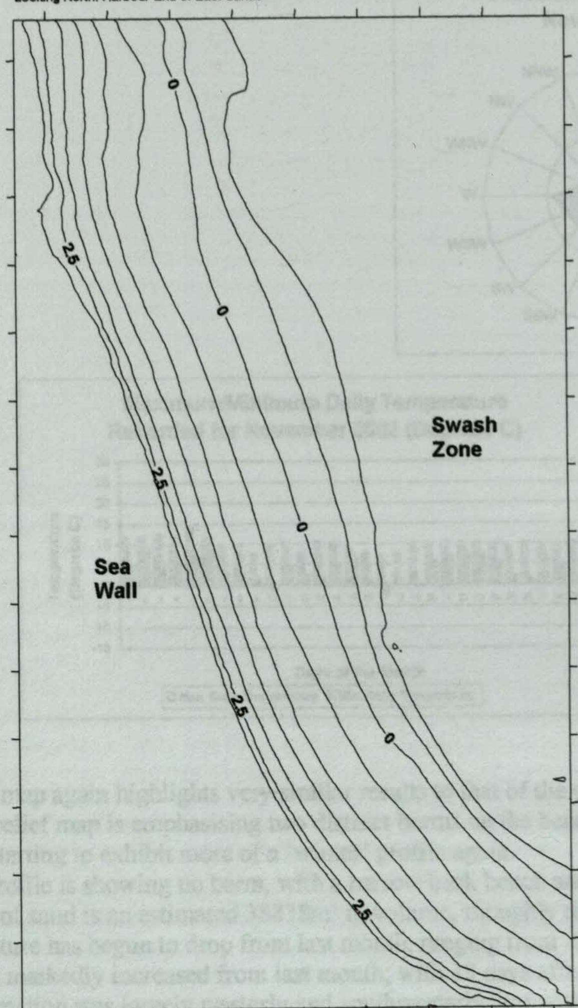
No comment can be made on wind direction, wind strength, wind speed or Beaufort Force.

The contours and shape of the profile allows us to deduce that there was little prevailing wind, and mostly calm weather conditions.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

NOVEMBER 2002

CONTOUR MAP 6th November 2002



SHADED RELIEF MAP 6th November 2002

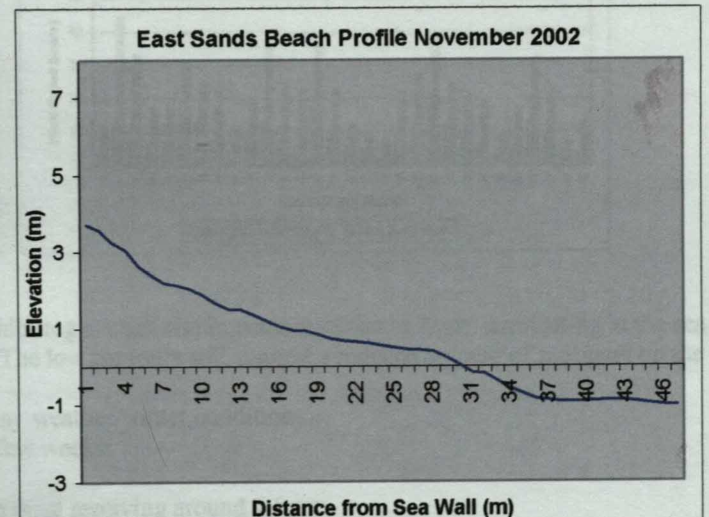
VOLUME COMPUTATIONS (m^3)

VOLUMES

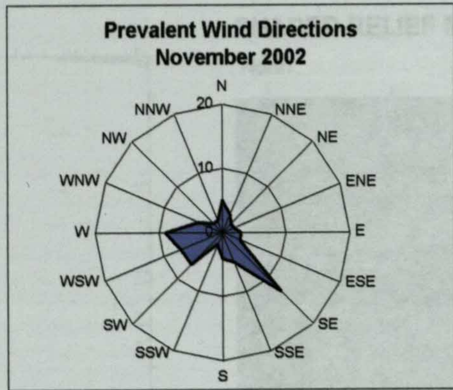
Approximated Volume by	
Trapezoidal Rule:	38838.195
Simpson's Rule:	38909.004
Simpson's 3/8 Rule:	38932.144

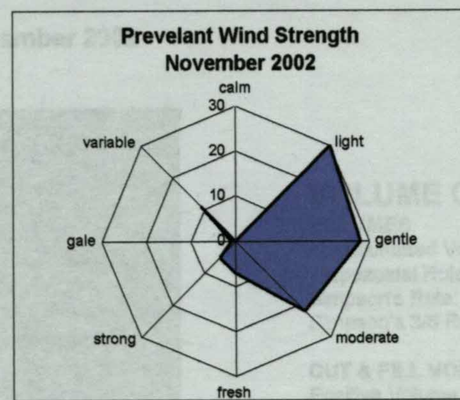
CUT & FILL VOLUMES

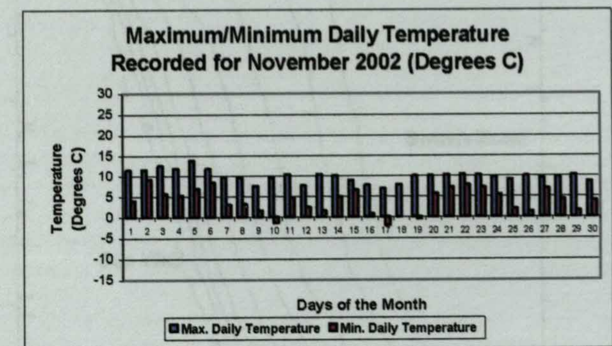
Positive Volume [Cut]:	88660.653
Negative Volume [Fill]:	49822.458
Cut minus Fill:	38838.195

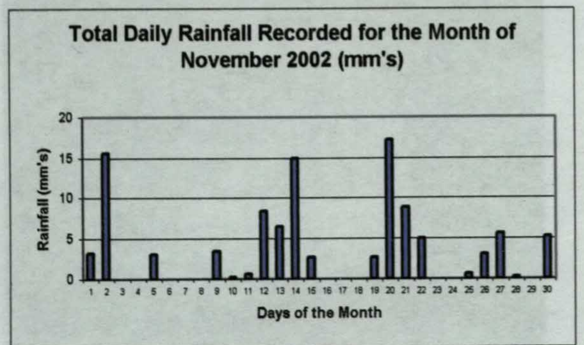


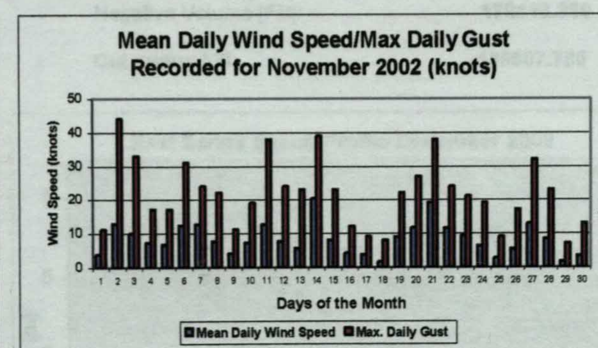
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











omments:

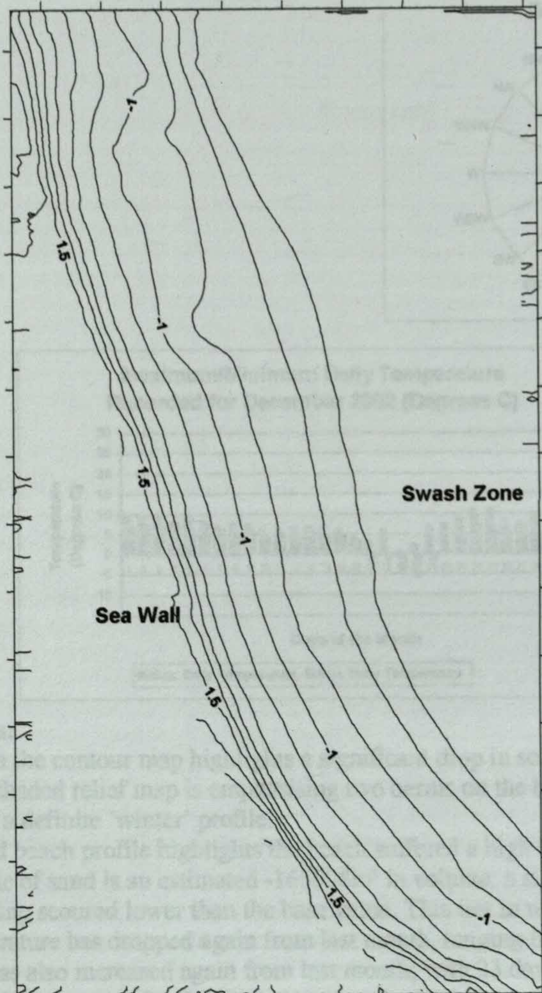
he contour map again highlights very similar results to that of the previous month of September, whereby the beach face is exhibiting a small rise in contour of 0m to 2.5m, terminating at the sea w
he shaded relief map is emphasising two distinct berms on the beach face, one at the sea wall and one near to the swash zone. The low contours still suggest a reduced amount of sediment on the b
that it is starting to exhibit more of a 'winter' profile again.
he beach profile is showing no berm, with a narrow back beach and evidence of reduced sediment volumes, indicative of stormy weather/winter conditions.
he volume of sand is an estimated 38838m³ in volume, rhoughly the same as the volume of September, indicating a calm last few weeks.
he temperature has begun to drop from last month, ranging from -2°C to around 8°C.
ainfall was markedly increased from last month; with 19 days affected and receiving anything from 1mm to 17mm a day, with most receiving around 7-8mm.
he wind direction was largely westerly and southwesterly, but with a high incidence of both southerly and southeasterly directions at times.
he wind strength varied from light through gentle to moderate with occurrences of strong strengths on some occasions, meaning the wind speeds would have been anything between 1 and 43 knots
he Beaufort Force would have been between 1 and 9, meaning there would have been a frequency of high and moderate to small waves, as well as large wavelets and crests, exhibiting evidence of
hite horses', with the probability of visibility reducing sea spray and dense sea foam.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

DECEMBER 2002

CONTOUR MAP 8th December 2002

Looking North: Harbour End of East Sands



Looking South: Kinkell Braes End of East Sands

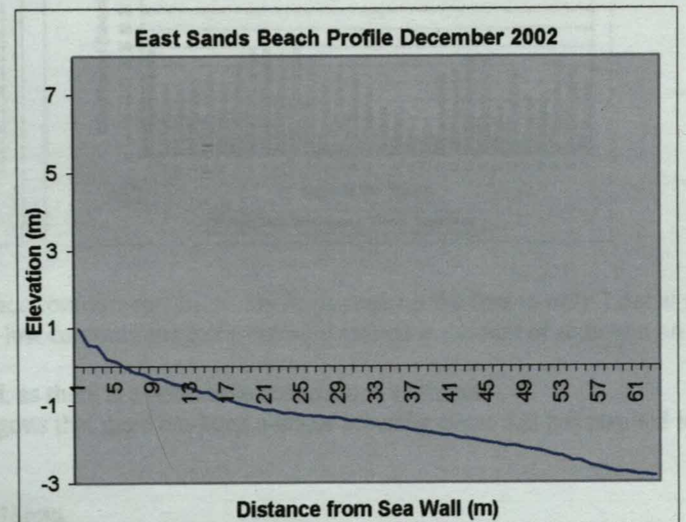
SHADED RELIEF MAP 8th December 2002

North

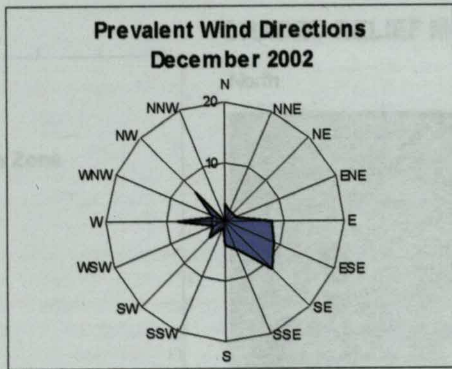
South

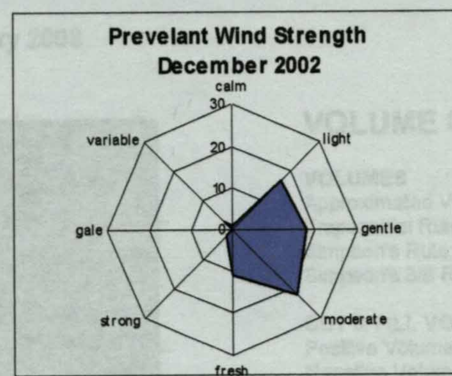
VOLUME COMPUTATIONS (m^3)

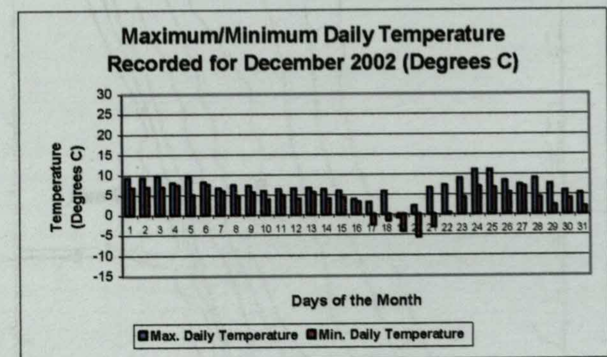
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**-165507.785**
Simpson's Rule:	**-165337.222**
Simpson's 3/8 Rule:	**-165559.158**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**12906.194**
Negative Volume [Fill]:	**178413.980**
Cut minus Fill:	**-165507.785**

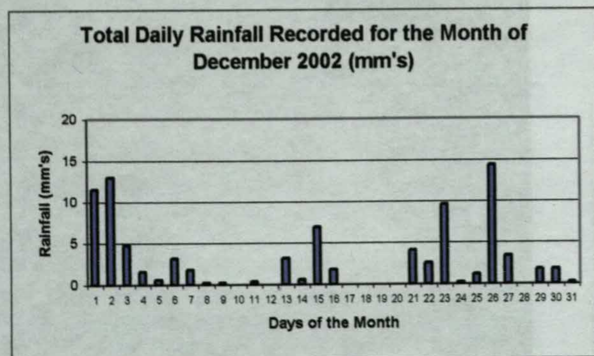


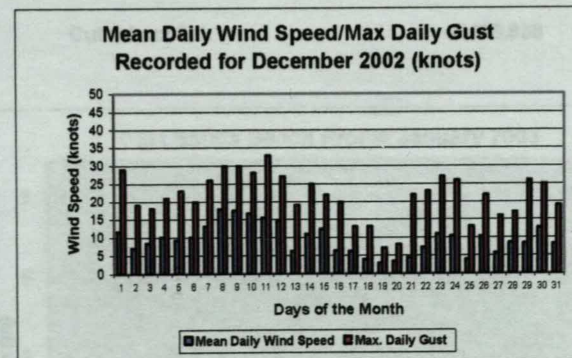
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

This month the contour map highlights a significant drop in sediment volume compared to the previous, whereby the beach face contours rise from -1m fairly high up the face to only 1.5m at the s wall. The shaded relief map is emphasising two berms on the beach face, one at the sea wall and right at the swash zone. The low contours suggest a sizeable reduction amount of sediment on the displaying a definite 'winter' profile.

The plotted beach profile highlights the beach suffered a high-energy event, resulting in severe scouring of the beach material, as there is a noticeable reduction in sediment.

The volume of sand is an estimated -165508m³ in volume, a significant decrease on last months figure. This volume also suggests that there has been a major scouring event that has resulted in the volume being scoured lower than the base value. This ties in with the exposure of bedrock talked about in Chapter 6.

The temperature has dropped again from last month, ranging from -10°C to around 8°C.

Rainfall was also increased again from last month; with 23 days being affected, receiving anything from 1mm a day to up to 15mm.

The wind direction was for the most part easterly through to southeasterly, but with a high occurrence of both westerly and northwesterly directions.

The wind strength varied from light through gentle to moderate with a frequency of strong strengths on some occasions, meaning the wind speeds would have been anything between 1 and 32 kno

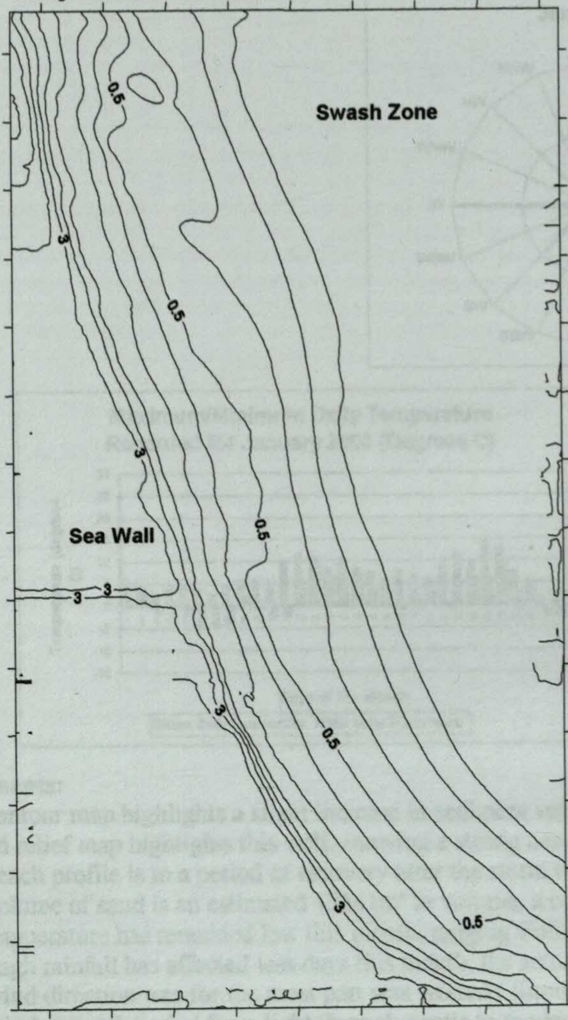
The Beaufort Force would have been between 1 and 7 so the sea would have been 'heaped up' with visible foam, as well as an incidence of large and moderate to small waves, as well as large wa and crests, all exhibiting evidence of 'white horses', and the probability of visibility reducing sea spray.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

JANUARY 2003

CONTOUR MAP 6th January 2003

Looking North: Harbour End of East Sands



Looking South: Kinkell Braes End of East Sands

SHADED RELIEF MAP 6th January 2003

North

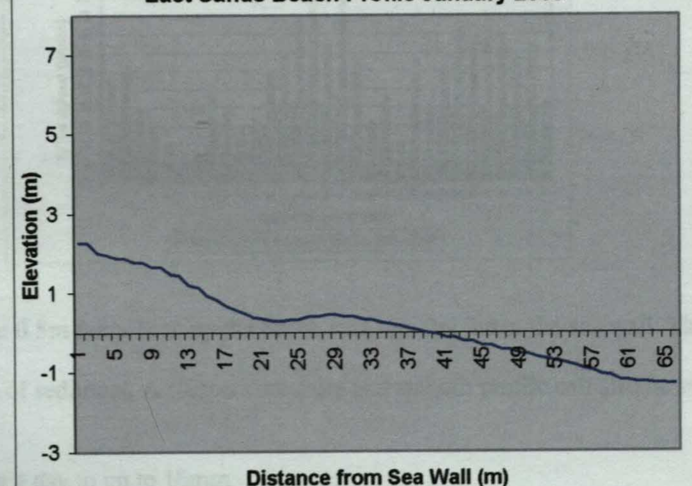
South

VOLUME COMPUTATIONS (m^3)

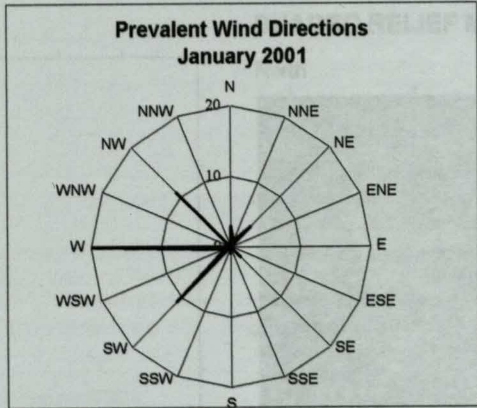
VOLUMES

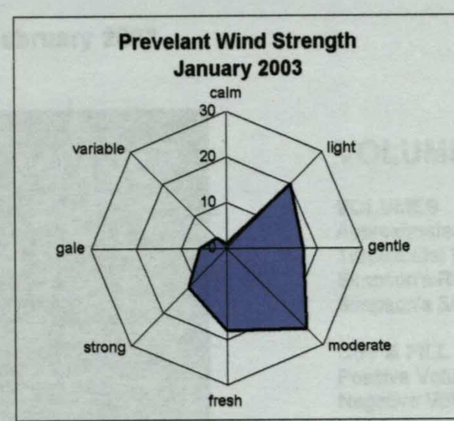
Approximated Volume by

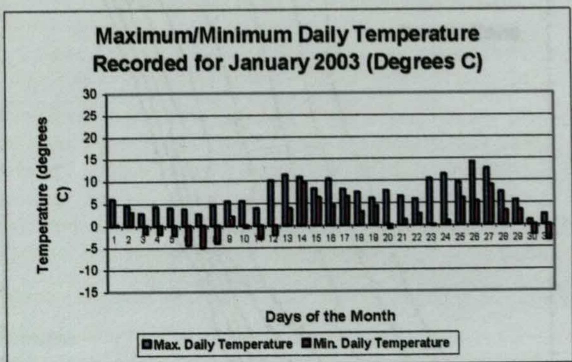
Trapezoidal Rule:	**45140.938**
Simpson's Rule:	**45169.170**
Simpson's 3/8 Rule:	**45250.419**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**83751.527**
Negative Volume [Fill]:	**38610.589**
Cut minus Fill:	**45140.938**

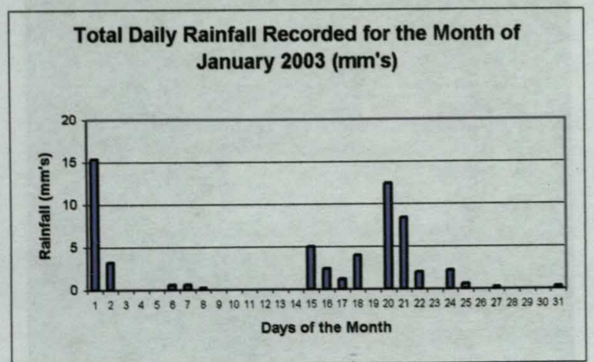


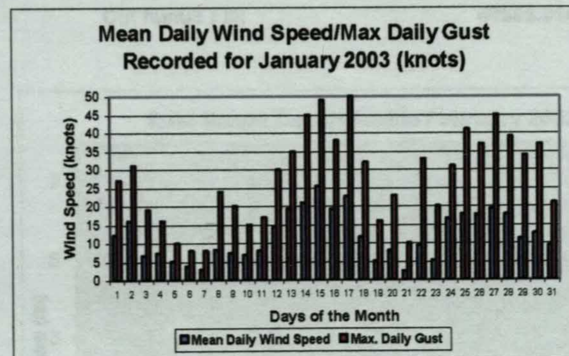
5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS











Comments:

The contour map highlights a slight increase in sediment volume compared to the previous month. The contours rise from 0.5m fairly high up the beach face to a flat 3m at the sea wall. The shaded relief map highlights this well, showing a strong beach step that runs along most of the sands.

The beach profile is in a period of recovery after the storm event of last month – a return to a smoother profile and return of sediment. A steeper foreshore and smooth profile can also be seen

The volume of sand is an estimated 45141m³ in volume, a considerable recovery from last months storm event.

The temperature has remained low this month, ranging from -10°C to around 10°C.

Although rainfall has affected less days this month, the actual amount that has fallen in a day has increased, ranging 1mm a day to up to 16mm.

The wind direction was for the most part was westerly through to northwesterly and, but with a small occurrence of a northeasterly direction.

The wind strength varied from light through gentle to moderate with a high frequency of strong and gale strengths on many occasions, meaning the wind speeds would have been anything between 1 and 50 knots in speed.

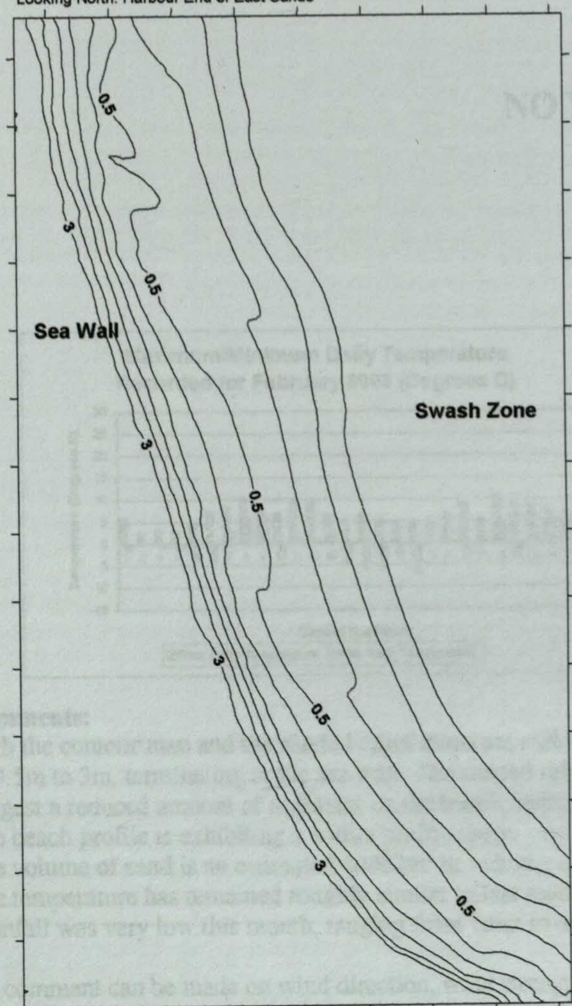
The Beaufort Force would have been between 1 and 9, possibly 10, so the study site would have been experiencing 'storm' conditions. Very high waves, with a rough, tumbling sea and very visibility would have been experienced on quite a few days this months. There would have been plunging and surging waves along with dense sea foam.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

FEBRUARY 2003

CONTOUR MAP 2nd February 2003

Looking North: Harbour End of East Sands



Looking South: Kinkell Braes End of East Sands

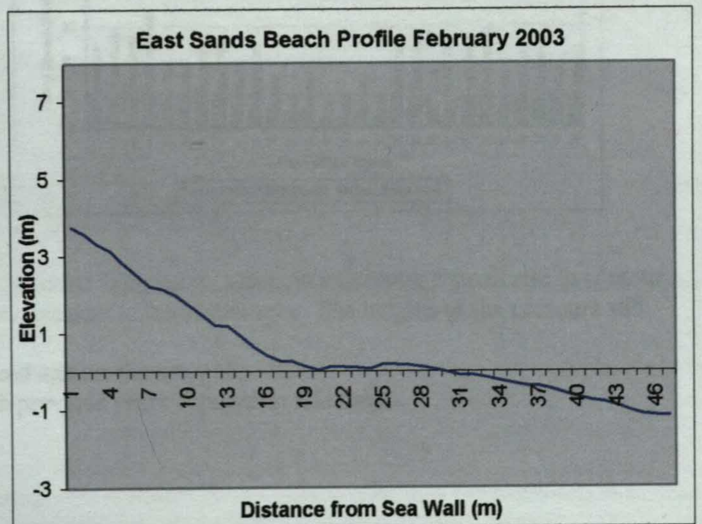
SHADED RELIEF MAP 2nd February 2003

North

South

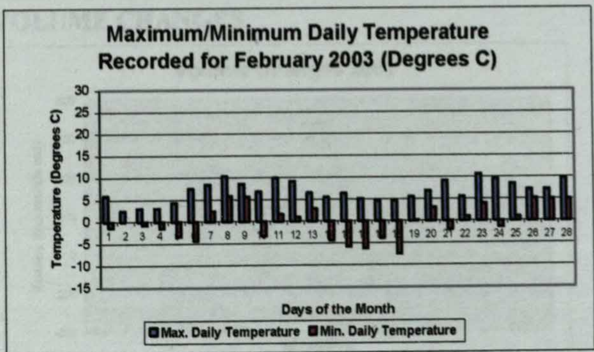
VOLUME COMPUTATIONS (m³)

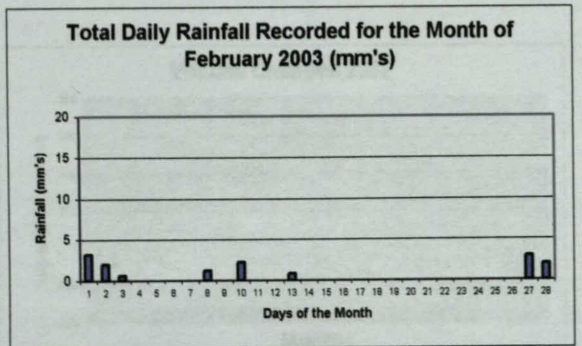
VOLUMES	
Approximated Volume by	
Trapezoidal Rule:	**40882.214**
Simpson's Rule:	**40929.628**
Simpson's 3/8 Rule:	**40982.401**
CUT & FILL VOLUMES	
Positive Volume [Cut]:	**82225.274**
Negative Volume [Fill]:	**41343.061**
Cut minus Fill:	**40882.214**

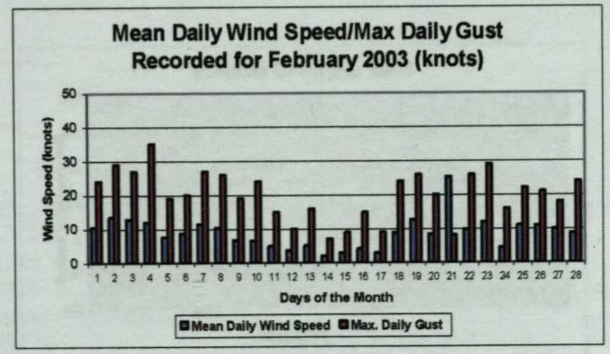


5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

NO WIND DIRECTION OR WIND STRENGTH DATA AVAILABLE







Comments:

Both the contour map and the shaded relief maps are still highlighting the same winter profile shown over the last three months. The profile, again, is exhibiting a small rise in contour of 0.5m to 3m, terminating at the sea wall. The shaded relief map once more illustrates two distinct berms at the sea wall and near to the swash zone. The heights of the contours still suggest a reduced amount of sediment on the beach, indicative of a 'winter' profile in this high-energy area.

The beach profile is exhibiting a winter profile shape – no berm to speak off, a narrow back beach, beach material stacked against the sea wall.

The volume of sand is an estimated 40882m³ in volume, a small decrease in January's volume, but concurrent with both previous years volumes at this time.

The temperature has remained roughly similar to last month, ranging from -10°C to around 8/9°C.

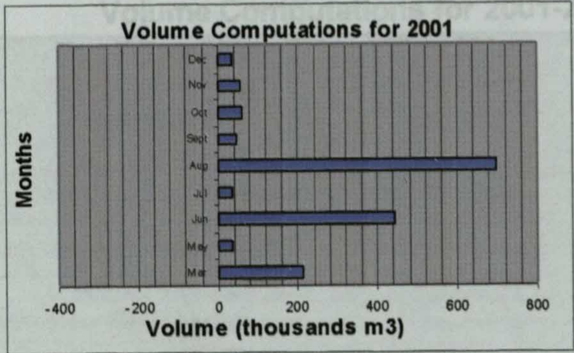
Rainfall was very low this month, ranging from 1mm to only 4mm and only 8 days affected days.

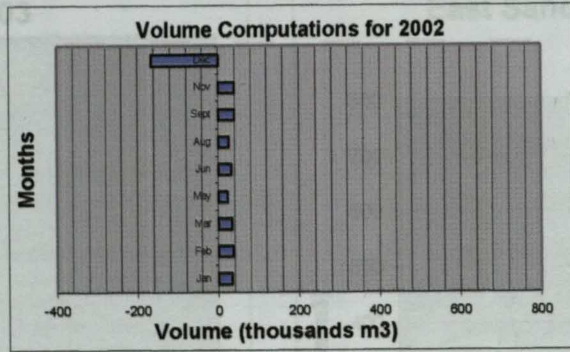
No comment can be made on wind direction, wind strength, wind speed or Beaufort Force.

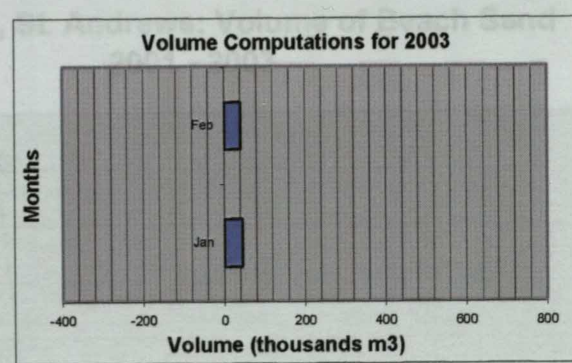
The contours and shape of the profile allows us to deduce that this was another month of high-energy forces, with a strong prevailing wind, and mostly turbulent weather conditions.

5.3 SURVEYING, VOLUMES AND CLIMATOLOGY RESULTS

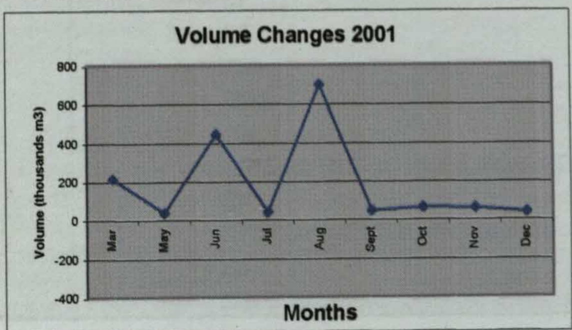
VOLUME COMPUTATIONS

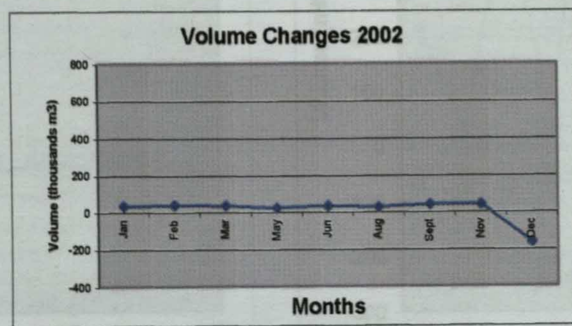


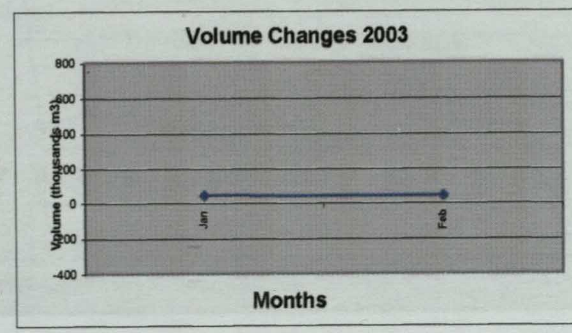




VOLUME CHANGES







Comments:

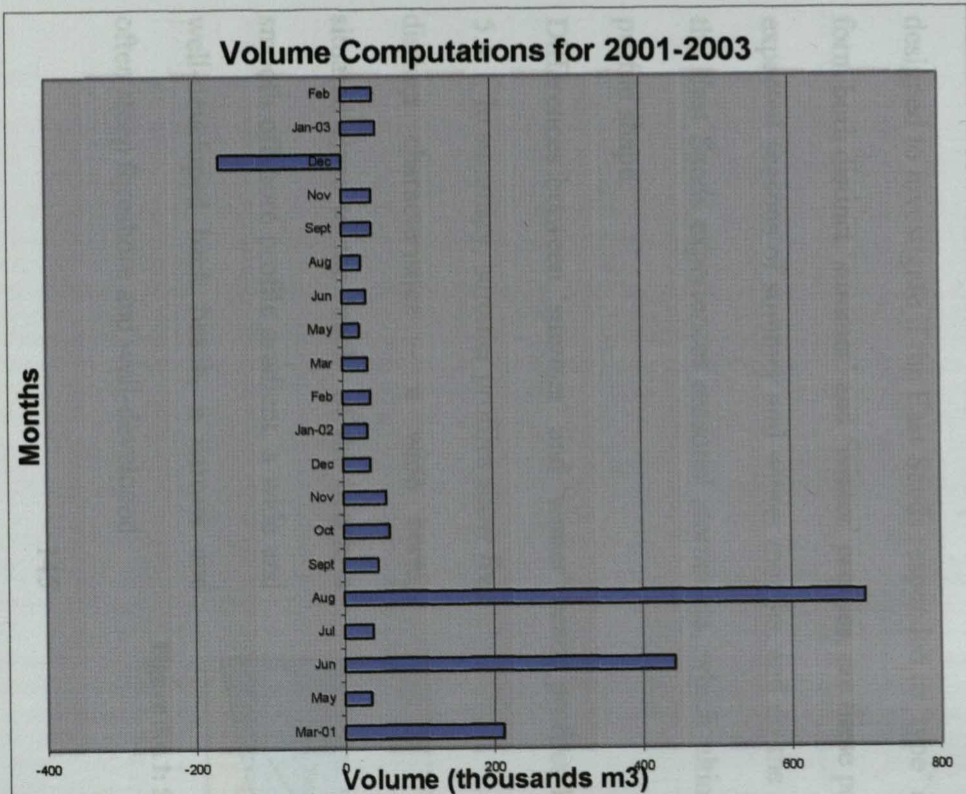
The volume computations for 2001 are exhibiting expected sediment movements between summer and winter shapes, as does 2002 but not in the same volumes as 2001, and there isn't enoug decisive data to make conclusive statements about 2003.

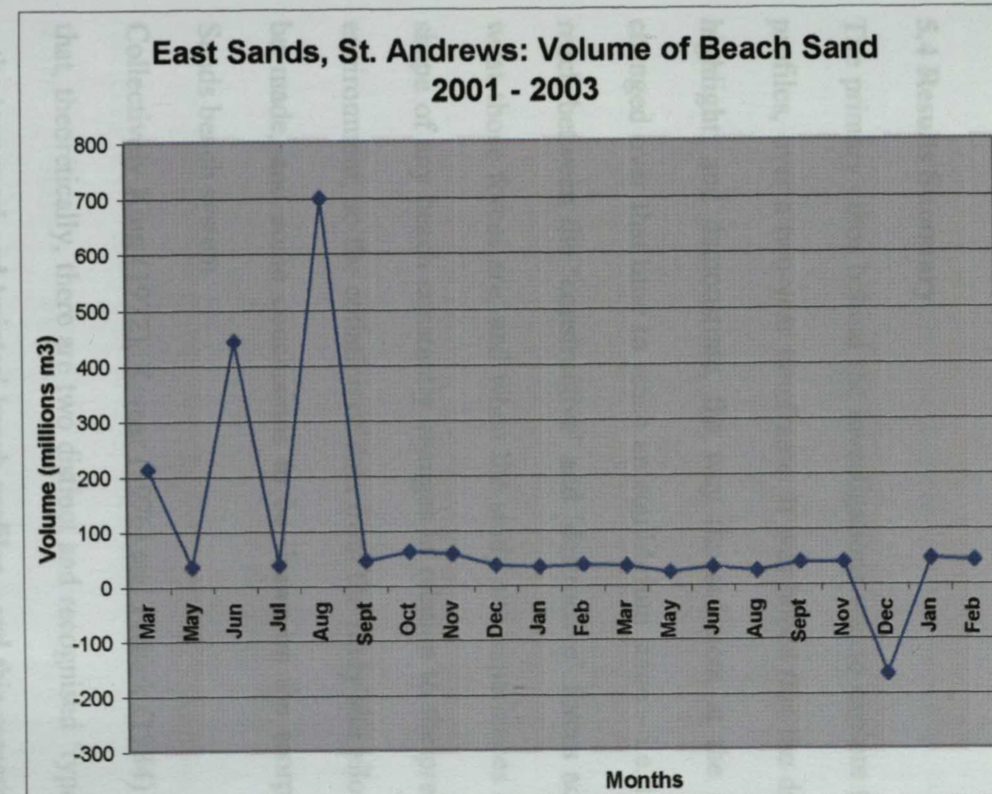
In 2001 from the months of March to May there is a decrease in volume of sediment on the East Sands – from just over 212 000m3 to 35 000m3. From there, until June, is a sharp increase ov‹ the next month, to over 440 000m3, as the beach is experiencing a fair-weather environment allowing for the accumulation of beach sediment. The results suggest that the study site the experienced a high-energy episode, that moved vast quantities of the sediment lain down in the previous month, as the volume for July decreased to roughly 38 000m3. Augusts' volume the increased dramatically to almost 700 000m3, while the remaining months fluctuated up and down – 45 000m3, 61 000m3, 57 000ms and 36 000ms for September, October, November an December respectively.

2002 displays a similar pattern to 2001, only in less volumes. There is no dramatic difference from month to month in the volume of sediment on the East Sands, with the exception of a negativ value for December. From January to December the figures fluctuate slightly here and there – January 33 000m3, February 37 000m3, March 34 000m3, May 22 000m3, June 31 000m3, Augu 25 000m3, September 39 000m3, November 39 000m3 and December –166 000m3. December has evidently experienced an intense high-energy episode, indicating a storm event to remove a much sediment as indicated in the results. At this time the bedrock of the East Sands was exposed for most of the month.

Nothing conclusive can be said about 2003, only that there is a slight decrease from Jan-Feb, from 45 000m3 to 41 000m3, which is concurrent with the idea that the East Sands experiences i winter months from Dec-Feb, and so it ought to have reducing sediment volumes as the stormy weather increases over the winter period.

**** N.B. all volume figures are rounded up ****





Comments:
Plotting the volume and volume change against every month of the research period allows an overview of the changes over the entirety of the research period. Allowing for a few anomalies, essentially the East Sands presents a somewhat expected pattern of both summer and winter seasons. Accordingly the sediment volumes are low through the winter periods – concurrent with a high-energy/stormy environment – and are higher through the summer periods - concurrent with a low-energy timeframe. The seasons of both spring and summer show intermittent changes, indicating that they are experiencing 'periods of recovery' in this season cycle of sediment movement.

2001 shows a generalised pattern of increasing volumes of sediment accumulating on the shoreface through the months of May to August – the 'summer' period, and then a general decrease towards the later end of the year. The sudden fallout from August to September and much lower volumes of the rest of the year suggest the beach experienced a consistently high energy environment, forcing the sediment to be moved offshore for a longer period of time than would normally be expected.

Interestingly also, is the vast scouring experienced in December 2002. This signifies a very intensive storm period that has systematically removed almost all of the sediment available at the East Sands – indeed, the underlying bedrock was exposed during this month. The results also highlight that this incident was likely to be a one off occurrence as by Jan 2003 most of the sediment, in relation to pre-December 2002 supplies, had been re-deposited back on the beach. January 2003, in particular, can be said to have experienced an intense period of recovery, whilst February 2003 seems to have experience 'rougher' weather than its pervious month, as its volume total is slightly decreased.

5.4 Results Summary

The primary ethos behind the investigations was to explore the changes in the beach profiles, over a two-year timeframe. It was hoped that the data collected would then highlight, and demonstrate, the way the sediment at the East Sands would have changed over that time to reach an equilibrium stage – i.e. the compromise it would reach between the 'constructive' and 'destructive' forces acting along its shoreline, what those forces are, and when the study site experiences them. We know that the shape of any beach constantly changes in relation to the prevailing conditions of the environment; so the collation of data from the study site allows some comparisons to be made, and some conclusions to be drawn on the morphodynamics of the East Sands beach system.

Collectively King (1972), Komar (1976) and Pethick (1984) have already established that, theoretically, there are two distinct and recognised 'types' of profile to be found – the 'summer' and 'winter' beach profiles - and this research was first and foremost designed to investigate if the East Sands responded to 'type' i.e. do the beach profiles form both distinct 'summer' and 'winter' profiles, are these profiles formed within the expected seasons of summer and winter months, and do the results would prove that the East Sands experiences seasonal storminess, which ultimately contributes to the profile shape.

Differences between 'summer' and 'winter' beach profiles look as shown in Figure 5.4.1. In summary, summer profiles show five distinct characteristics – a wide berm, situated close to the 'back' of the beach, a smooth offshore profile gradient, a wide and well-developed back beach, a narrow and often steep foreshore and well-developed

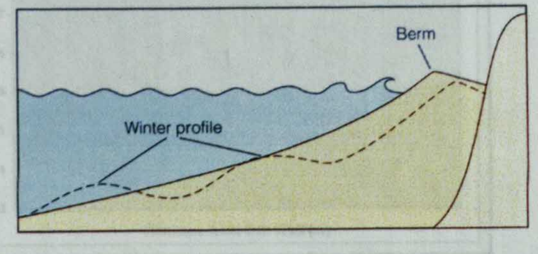


Figure 5.4.1: Summer and Winter Profile Shapes, Dutch et al, 1998.

sandbars in the low tide and immediate offshore areas. While, in contrast, winter profiles can be characterised by only three criteria – no berm, a narrow back beach and sand bars that have formed parallel to the shoreline, usually between 10 and 20m out from the shoreline.

Monthly surveys across the East Sands beach, along lines perpendicular to the seawall to the low water mark, have provided sets of beach profiles which can be directly compared through time. The profiles measured reflect both summer and winter conditions with transitional intermediate conditions in spring and autumn.

- **Summer Profiles**

The results reveal that the profiles collected at the study site have exhibited some classic 'summer profile' characteristics throughout the summer months, in particular the months of June to August, for the summers of both 2001 2002.

The profiles selected for Figure 5.4.2, drawn from the 2001 data set, emphases the profile shapes for June, July and August 2001. All three profiles clearly exhibit the smooth profiles expected for these summer months. The plotted graphs allow you to identify, and single out, a single transect of the East Sands survey.

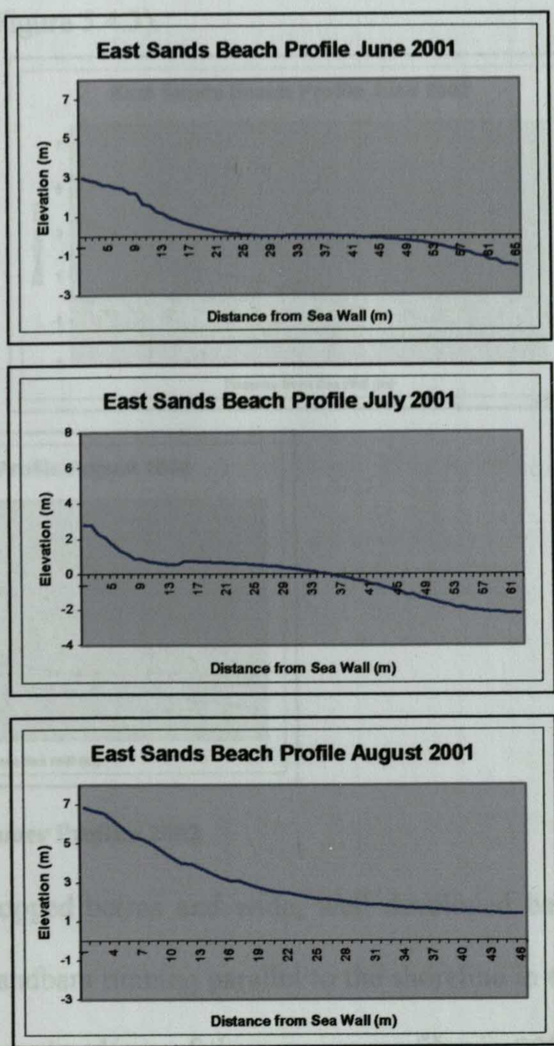


Figure 5.4.2: Summer Profiles 2001

Distinct flat topped berms can be found on all three of the 2001 summer examples, all of which display wide back beaches. The profiles reveal steep beach faces where the sediment is deposited against the sea wall, and narrow foreshores. All of the profiles formed under fair-weather conditions, slope gradually towards the swash zone. Considerable accretion of sands took place during the early summer months, culminating in greatest beach surface levels in August of 2001.

During the summer of 2002 similar beach profiles were recognised with the flat-topped berms, wide well developed back beaches and narrow foreshores with longshore bars parallel to the shoreline at low tide.

The beach profiles from the summer months of 2002 are very similar to those of 2001, with recognisable summer profile features (Figure 5.4.3).

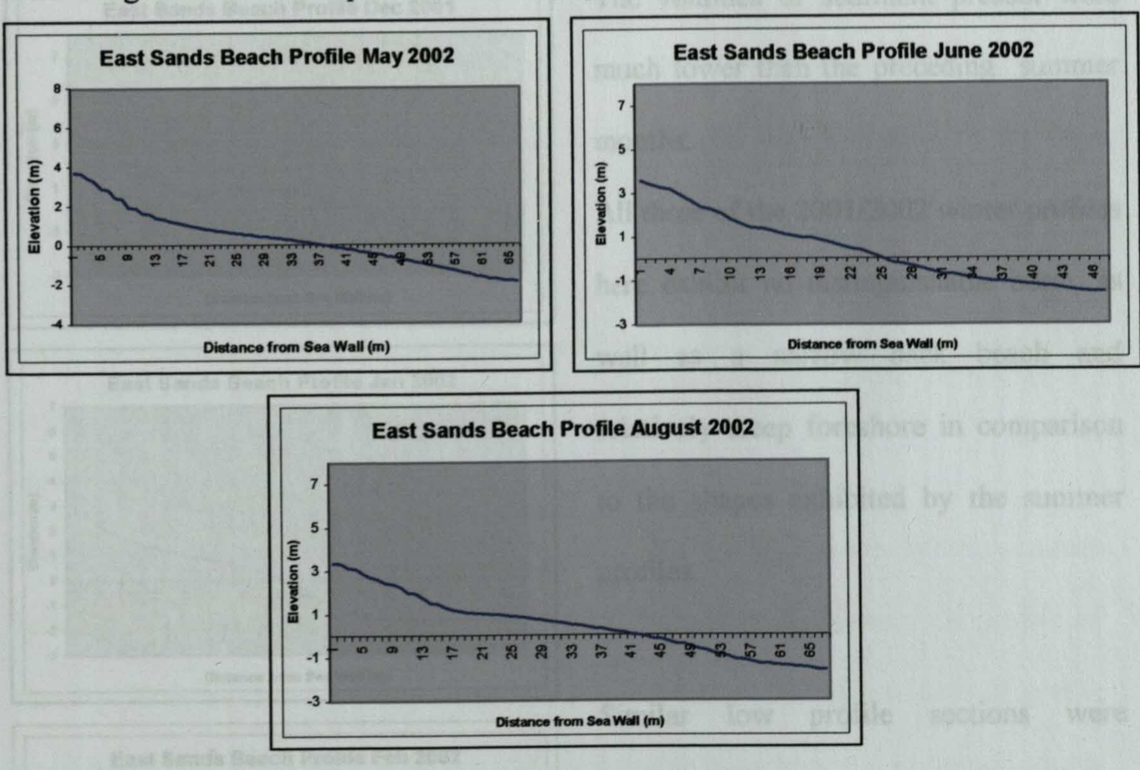


Figure 5.4.3: Summer Profiles 2002

Again, there is an incidence of both flat-topped berms and wide, well developed back beaches, as well as narrow foreshores and sandbars running parallel to the shoreline in the low tide area. The profiles from 2002 repeat the shape of the summer profiles in 2001, confirming, that although they changed shape in the intervening months, they changed shape in the intervening months, they regained the distinctive summer profile features the following year.

- **Winter Profiles**

In contrast to the summer profile shapes, the profiles surveyed during the winter months reveal different patterns e.g. winter months being from November through to February. 'Winter' profiles are expected to display an absence of berms, only narrow back beaches and low level surfaces of sediment. Figure 5.4.5 displays shore profiles taken from the winter months of 2002, and into the beginning of 2003, that exhibit characteristics concurrent with 'winter' profile shape.

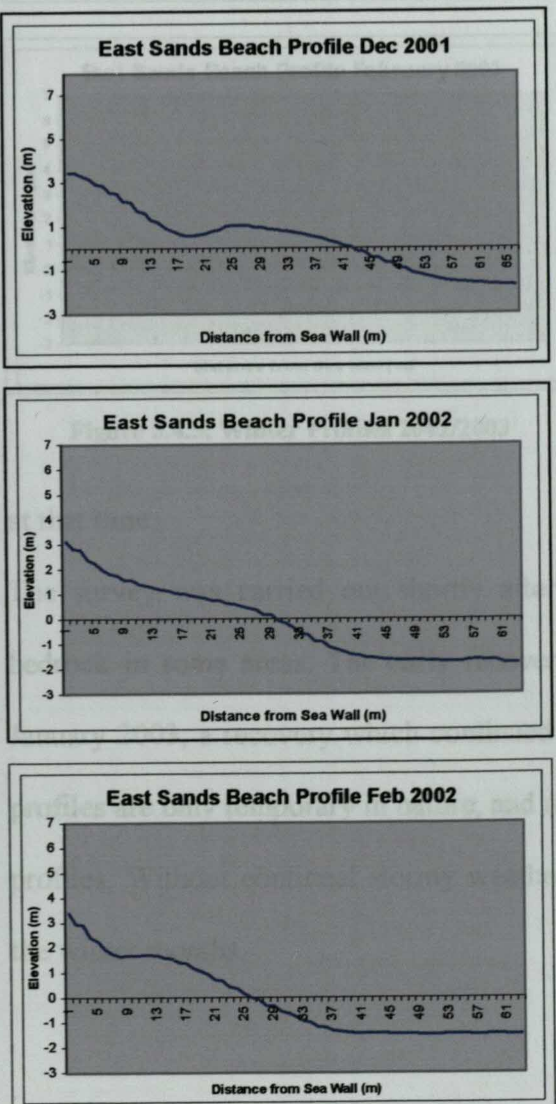


Figure 5.4.4: Winter Profiles 2001 - 2002

The volumes of sediment present were much lower than the preceding summer months.

All three of the 2001/2002 winter profiles here exhibit no distinguishable berm, as well as a narrow back beach and relatively steep foreshore in comparison to the shapes exhibited by the summer profiles.

Similar low profile sections were obtained during the winter of 2002-2003, heavy storms having led to severe erosion in December 2002, but the sands gradually returned to the beach in January and February.

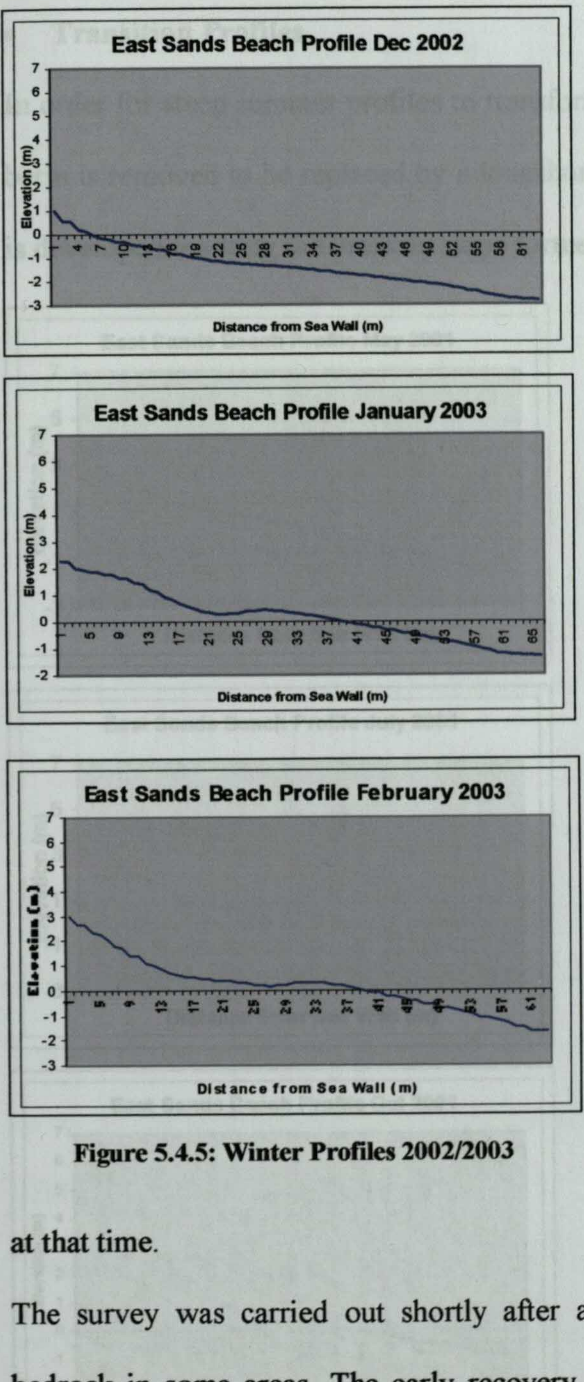


Figure 5.4.5: Winter Profiles 2002/2003

Again, all three examples emphasise definitive 'winter' beach profiles shapes for this season.

The shore profiles reveal no evidence of berms present, in direct contrast to distinct berms found on the preceding summer profiles. These profiles also display narrow back beaches, as well as smaller/shallower volumes of sediment stacked against the sea wall, concurrent with an expected winter profile shape.

The profile plotted for December 2002 is exceptionally low in relation to the zero line, indicating that there was very little sediment on the beach at that time.

The survey was carried out shortly after a severe onshore storm which exposed bedrock in some areas. The early recovery of the beach is reflected the profile of January 2003, a recovery which continued into February 2003.These kinds of severe profiles are only temporary in nature, and are extreme in comparison to normal winter profiles. Without continual stormy weather a 'period of recovery' will begin during the winter months.

- **Transition Profiles**

In order for steep summer profiles to transform into relatively low winter profiles the berm is removed to be replaced by a longshore bar at low tide level, and a beach step is developed marking the break in slope formed by breaking waves.

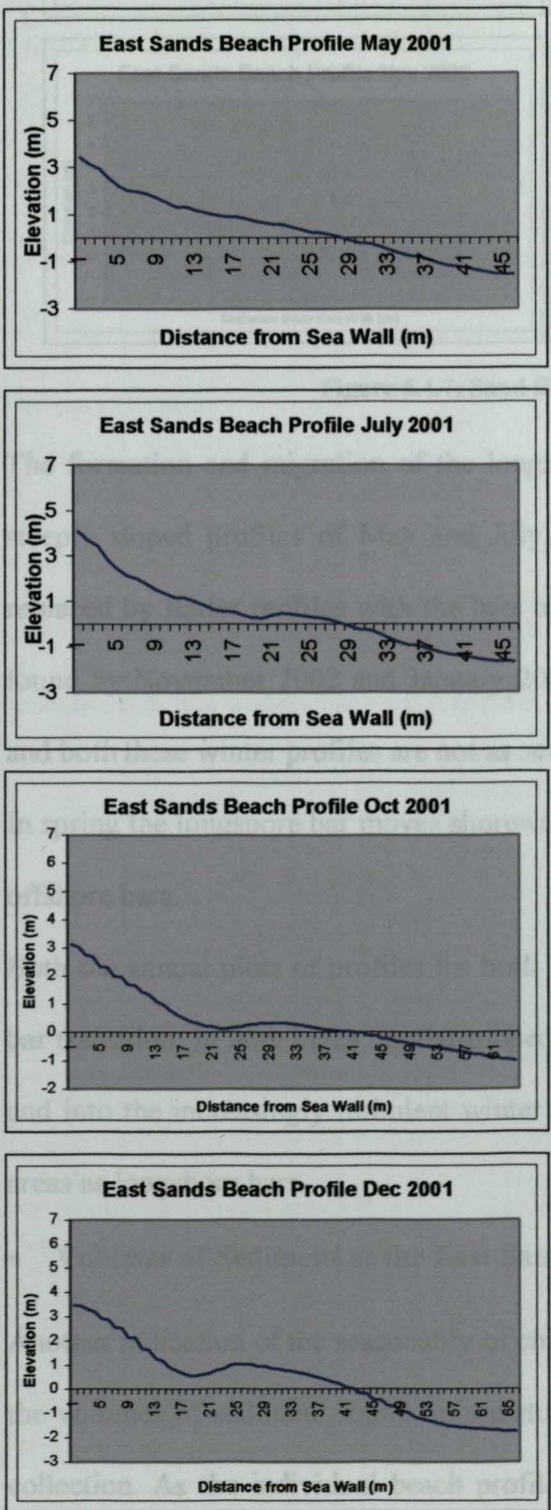


Figure 5.4.6: Sand Bar Migration 2001

This sand bar migration is identified for both 2001 and 2002 in Figures 5.4.6 and 5.4.7.

The transition from steep summer to shallow winter profiles is mainly marked by the removal of the flat-topped berm - formed at the limits of wave swash - and the deposition of a longshore bar just below the low tide level.

This migration is highlighted with the months of May, July, October and December of 2001. The summer profiles here are relatively steep, smooth and possess berms.

Towards the end of the year the profiles reveal the sediment to be present in longer profiles that stretch into the low tide area. There is a pronounced break in slope at the position of the breaking waves between 21m and36m from the back wall.

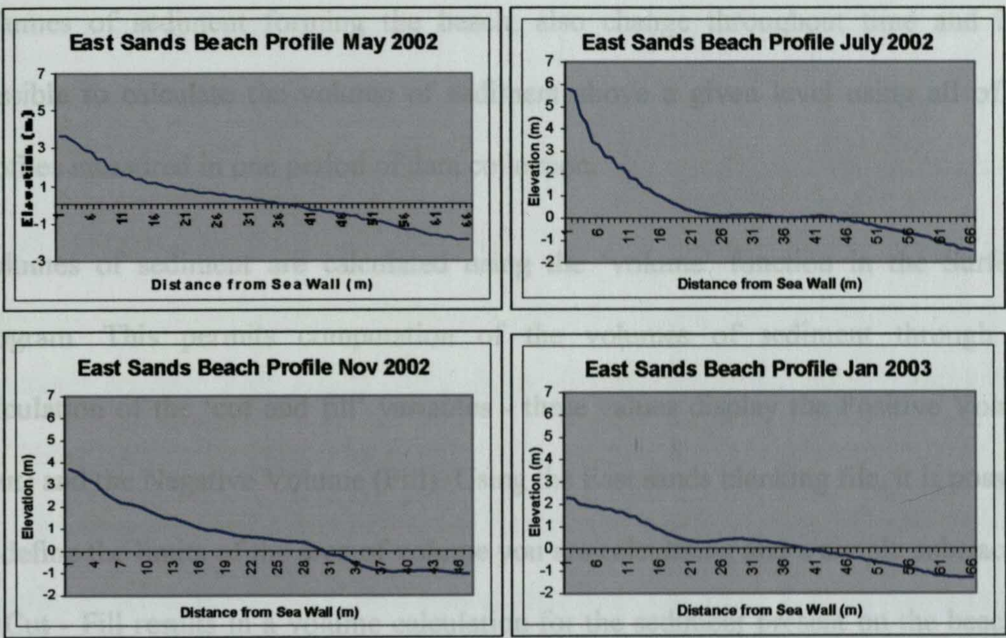


Figure 5.4.7: Sand Bar Migration 2002

The formation and migration of the longshore bar was repeated in 2002, when the steeply sloped profiles of May and July, with their wide, flat-topped berms were replaced by flatter profiles with the bars in their lower sections. The overall gradient found by November 2002 and January 2003, is far reduced from earlier in the year, and both these winter profiles are not as smooth as their summer counterparts.

In spring the longshore bar moves shoreward as sediment transfers landward from the offshore bars.

Both the annual plots of profiles for both 2001 and 2002 display the berm-longshore bar transition. In both cases the flat-topped berm is removed after the summer period, and into the increasingly turbulent winter months deposited in the near and offshore areas as longshore bars.

- **Volumes of Sediment at the East Sands**

Another indication of the seasonality of changes on the beach lies in the calculation of the volumes of sediment found on the study site during any one session of the data collection. As the individual beach profiles show consistent patterns of change, the volumes of sediment forming the beach, also change throughout time and it is possible to calculate the volume of sediment above a given level using all of the profiles measured in one period of data collection.

Volumes of sediment are calculated using the 'volume' function in the Surfer 7 program. This permits computation of the volumes of sediment through the calculation of the 'cut and fill' variables - these values display the Positive Volume (Cut) and the Negative Volume (Fill). Using the East sands blanking file, it is possible to define the limits of the area of volume you are calculating and a simple subtraction of Cut - Fill results in a volume calculation for the sediment present on the beach at the survey time.

It is expected that there ought to be greater volumes of sediment deposited on the shoreface during the summer months, and less so during the winter months. The East Sands, then, does indeed exhibit greater volumes of sediment during the summer months, and less during the winter months, for both 2001 and 2002.

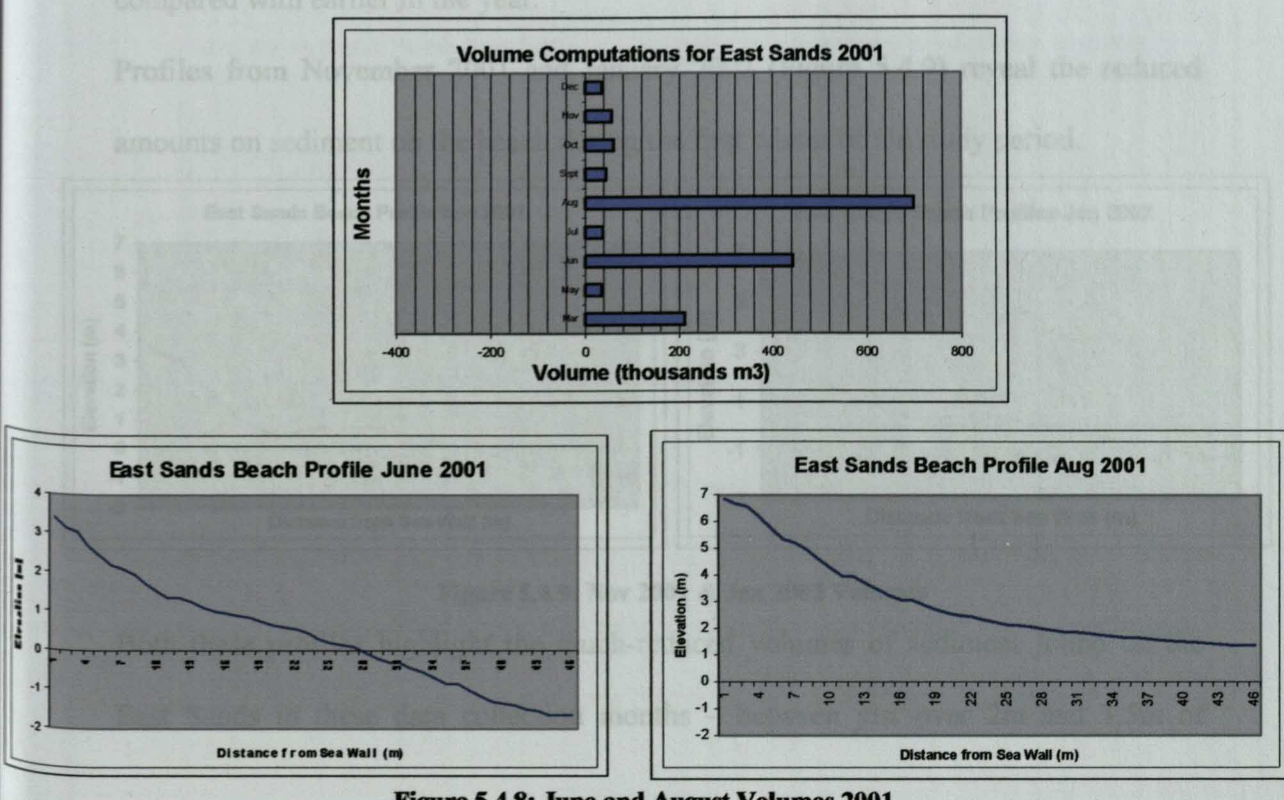


Figure 5.4.8: June and August Volumes 2001

The Volume Computation bar chart (Figure 5.4.8) displays the annual change, month by month, in sediment volume for 2001. It reveals that not only are the summer profiles smoother, but they also tend to have far greater volumes of sediment than the winter months, at the latter end of the year. Volume addition demonstrates accretion, and 2001 experienced greater volumes in June and August, in this case the volume of sediment on the East Sands rises from 442601.098m³ in June , through to 699268.278m³ in August. The profile from August displays a strong example of sediment deposition in a summer period while also revealing a marked increase in the volume of sediment on the East Sands at this time. The shore face elevation against the sea wall, reaches up to roughly 3.5m in June, and 7m in August, highlighting that, prior to data collection; the beach experienced a particularly fair weather environment. The most striking contrast between the summer and winter profiles is in the sharp decrease in the volume of sand present in winter. The entire dataset highlights a noteworthy difference in the volumes of sand deposited during these months, compared with earlier in the year.

Profiles from November 2001 and January 2002 (Figure 5.4.9) reveal the reduced amounts on sediment on the beach during the first winter of the study period.

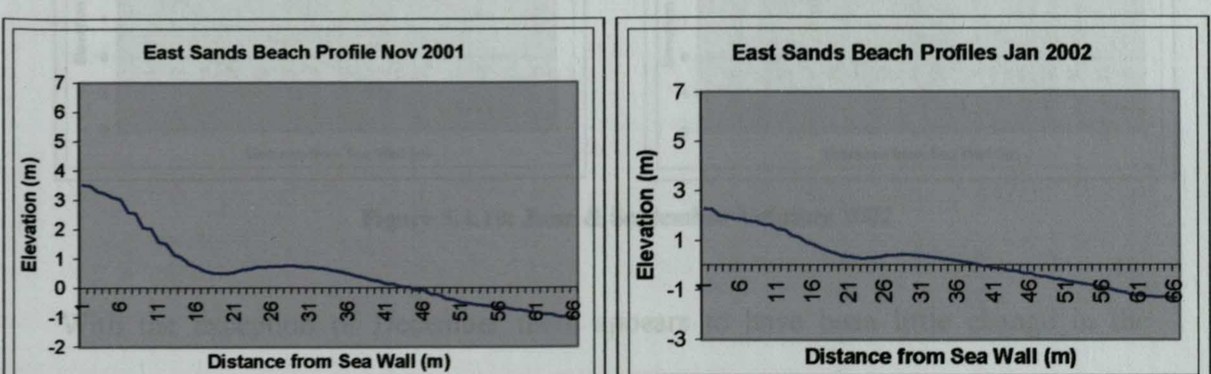


Figure 5.4.9: Nov 2001 & Jan 2002 Volumes

Both these profiles highlight the much-reduced volumes of sediment found on the East Sands in these data collection months – between just over 2m and 3.5m of elevation stacked against the sea wall – concurrent with volume reduction in winter months. Between June and August 2001 there was between 442601.098m³ and 699268.278m³ of sediment deposited on the beach, but by the winter months of November 2001 and January 2002 it was reduced to 35752.399m³ and 32732.719m³ respectively.

Again the year of 2002 exhibits both larger volumes of sediments in the summer, and reduced volumes by the winter season, confirming the theory of annual volume change on a shoreline. Figure 5.4.10 picks out June and September 2002 as examples of deposition volumes during the summer months of 2002.

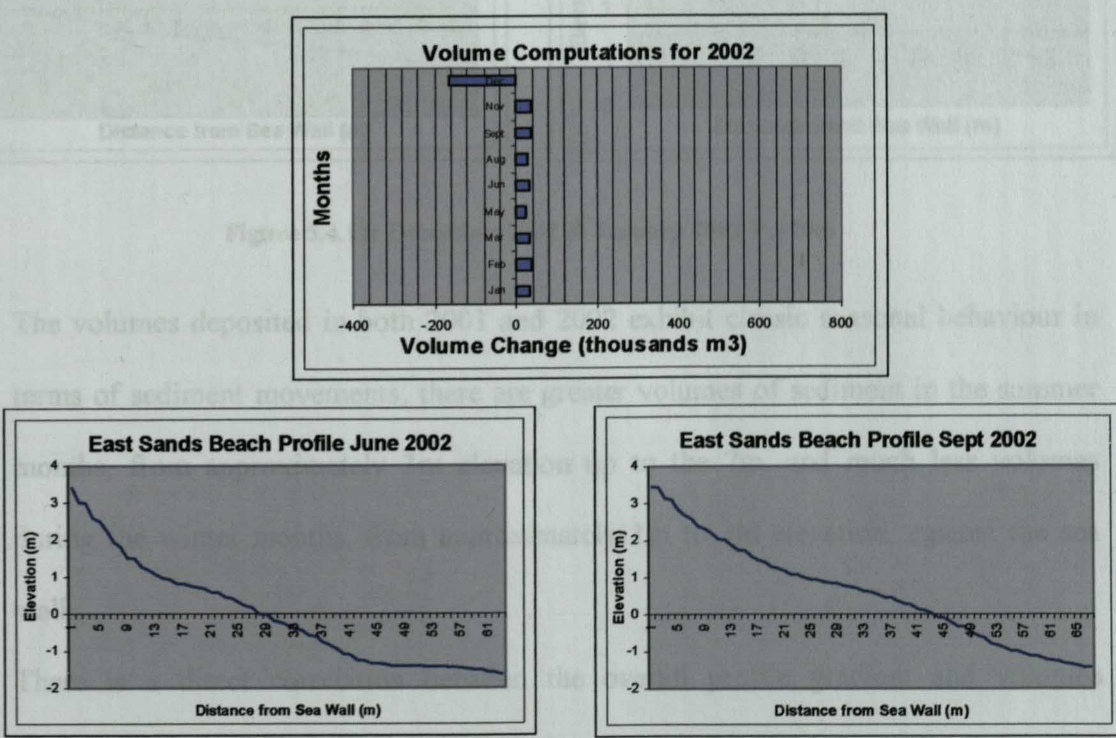


Figure 5.4.10: June & September Volumes 2002

With the exception of December there appears to have been little change in the volumes of sediment, on the beaches in 2002. The bar chart suggests that the volume of sand on the beach was virtually unchanging throughout most of the year, until December. Both of the profiles indicate that the sand reached up to an elevation above

3m, where the sand was stacked against the sea wall, reaching a level between 0.5 and 1.5m above that of the previous winter.

In comparison, the winter profiles taken in this annual cycle, of December 2002 and January 2003, show a marked difference in the volumes of sediment of the beach face. In this case, only from about 1m to just over 2m elevation, a loss of volume to the beach face of between 1m – 3m, compared with the preceding summer months.

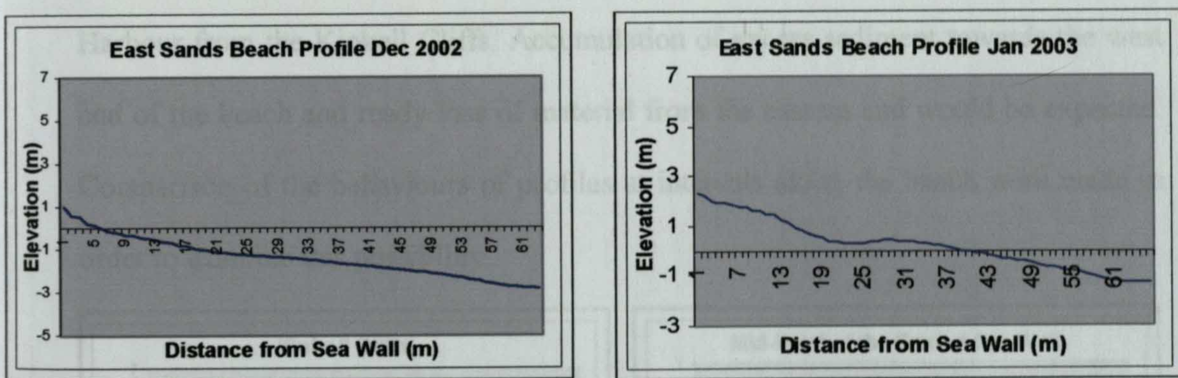


Figure 5.4.11: December 2002 & January 2003 Profiles

The volumes deposited in both 2001 and 2002 exhibit classic seasonal behaviour in terms of sediment movements; there are greater volumes of sediment in the summer months, from approximately 3m elevation up to the 7m, and much less volumes during the winter months, from approximately 1m to 3m elevation, against the sea wall .

There is a direct correlation between the overall profile gradient and volumes deposited, whereby the greater volume of sediments deposited, generally the steeper the gradient found – particular against the sea wall section. Pethick (1984) also theorises that the gradient of a profile is also in direct correlation with the wave variability of the study site. Not only does the stormier the environment generate more sediment entrainment, and therefore loss of gradient, but he also claims that the wave breaker type can also affect the sediment deposition and entrainment processes. Low, flat swell waves (spilling breakers) are generally found in the summer months, whereas high, steep storm waves are found in the winter period (surging breakers).

- **Alongshore Movement of Sediment**

The research of Sarrikostis (1986) and Al-Washami (1996) has shown, that in the head of St. Andrews Bay, the sediment generally migrates from Fife Ness towards the Tay Estuary. On the East sands this should be manifested as motion towards the Harbour from the Kinkell Cliffs. Accumulation of excess sediment towards the west end of the beach and ready loss of material from the eastern end would be expected. Comparison of the behaviours of profiles at intervals along the beach were made in order to examine this possibility.

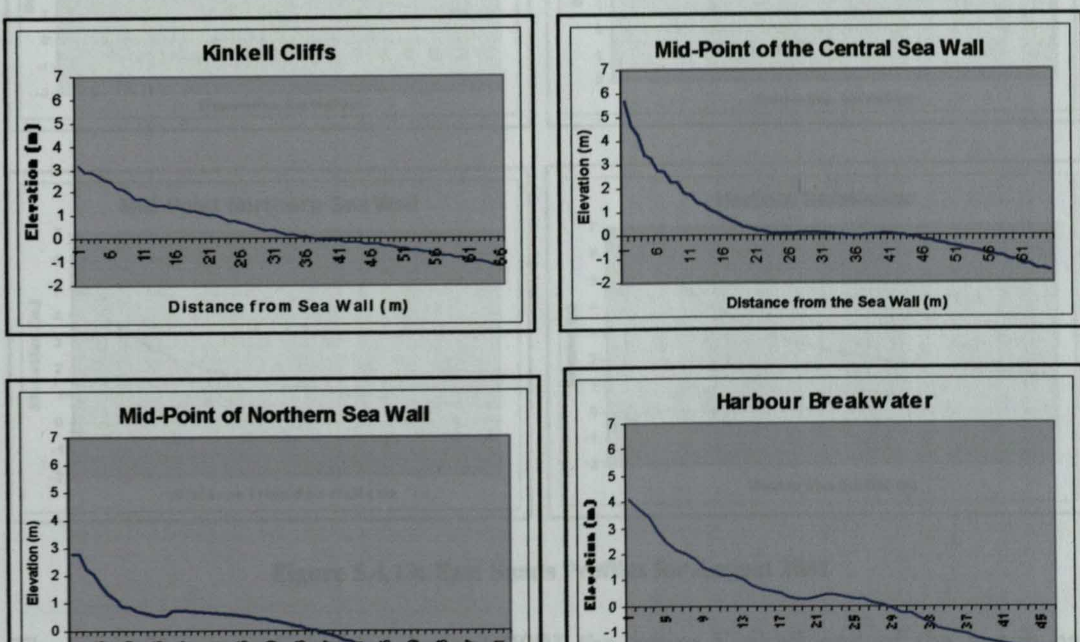


Figure 5.4.12: East Sands Profiles for July 2001

The profiles measured in July 2001 (Figure 5.4.12) reveal that at the Kinkell Cliffs a flat profile extended up to 3m, above OD, at the back wall. By the middle of the central wall, the concave profile rose sharply to a level of 5.7m above OD. By mid-point of the northern section of the seawall, the lower part of the profile incorporates a beach foot bar with a landward hollow at the foot of an upper concave section, which rises to 2.7m at the seawall. At the harbour breakwater, the profile shows a reduced beach foot, bar and hollow below a flatter, but still concave, upper section reaching 4m above OD.

A similar series of profiles measured in August 2001 (Figure 5.4.13), just one month later, reveals that at all sites substantial accretion had taken place. Although there was some concavity in each profile, it was on a very reduced scale, and in essence all profiles were flat, showing resemblance to the July 2001 profile at the Kinkell Cliffs.

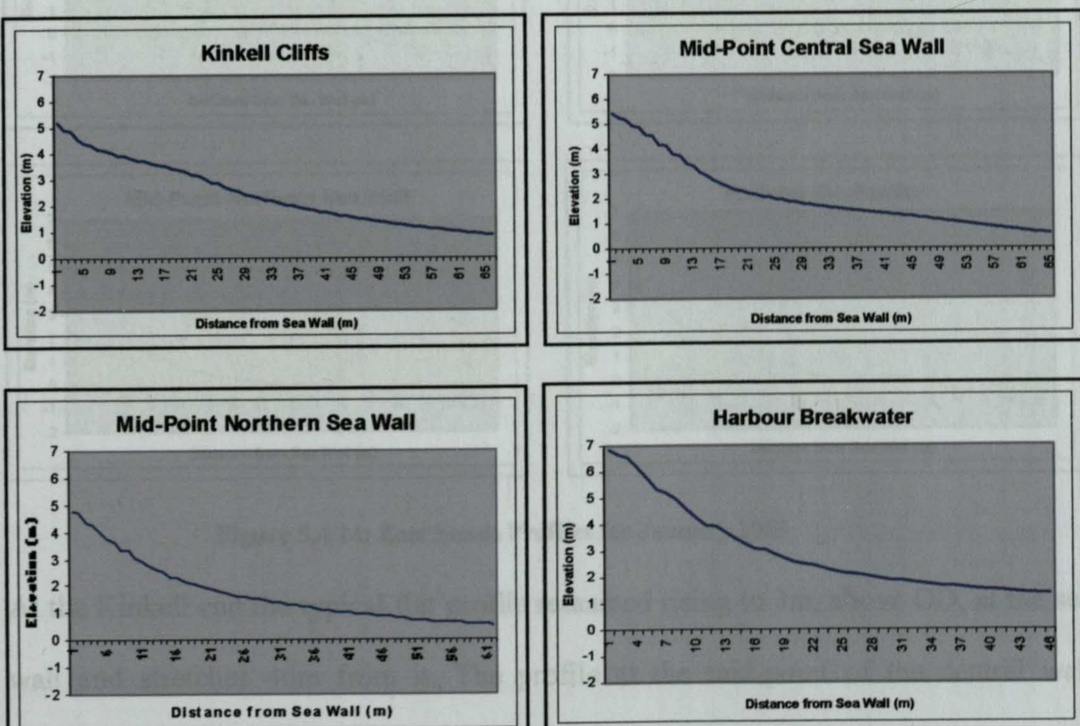


Figure 5.4.13: East Sands Profiles for August 2001

These profiles reveal that by August 2001 the entire Kinkell end of the beach had built upwards, to reach 5.5m OD at the back wall. At the middle of the central wall, again the entire profile had risen, albeit terminating at a slightly decreased back wall level of 5.4m. A similar, very flat, profile, lacking the beach foot bar and rising to 4.9m at the back wall, was observed off the northern wall and the greatly elevated harbour wall section was again flat and lacking the beach floor bar as it reached up to

7m against the harbour breakwater. On all sections in August the profiles remained above OD at a distance of 65m from the back wall.

Beach profiles from January 2003 reveal that on all sections of the coast a substantial reduction to the total of the beach surface had taken place since August 2002.

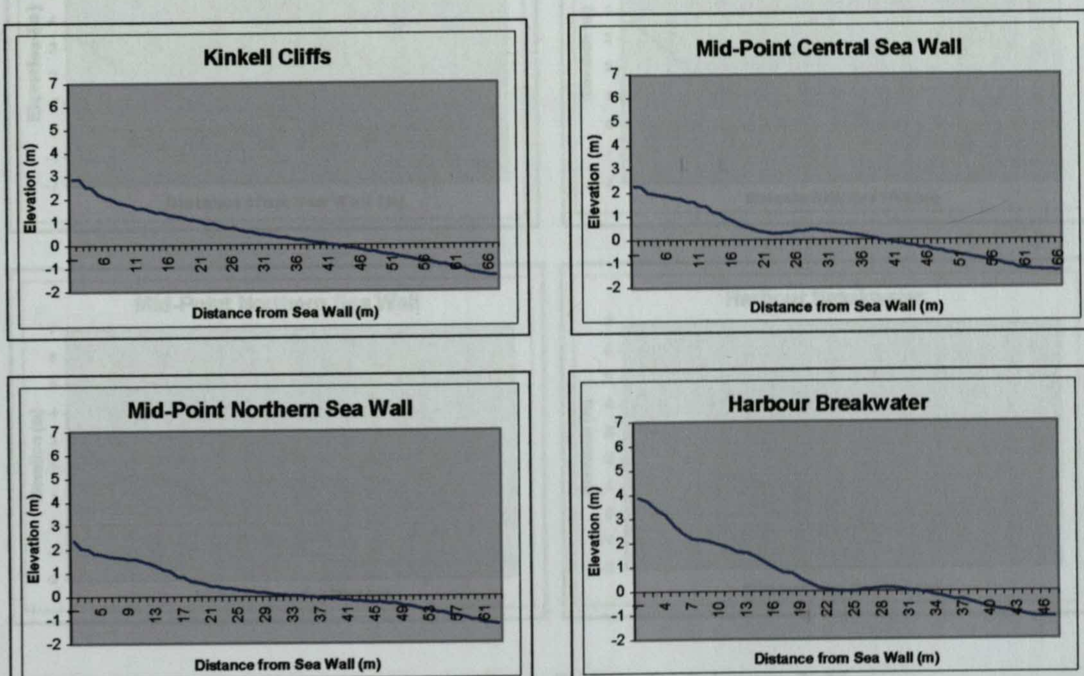


Figure 5.4.14: East Sands Profiles for January 2003

At the Kinkell end the typical flat profile remained rising to 3m, above OD, at the sea wall and stretches 40m from it. The profile at the mid-point of the central wall revealed a beach foot bar between 26 and 40m, a landward hollow and a steep beach face below a flat-topped berm reaching 2.4m at the seawall. A basically flat curve was present by the centre of the northern wall, with a steep section beneath a wide upper beach terrace just below 2m OD. The profile reached 2.4m at the sea wall. No beach foot was detected. At the harbour breakwater the mass of sands above OD reached only 20m from the sea wall, the profile rising steeply to 4m at the breakwater. A low beach foot bar extended to 30m from the seawall was present.

The profiles for February 2003 (Figure 5.4.15) can also serve to highlight this alongshore sediment movement.

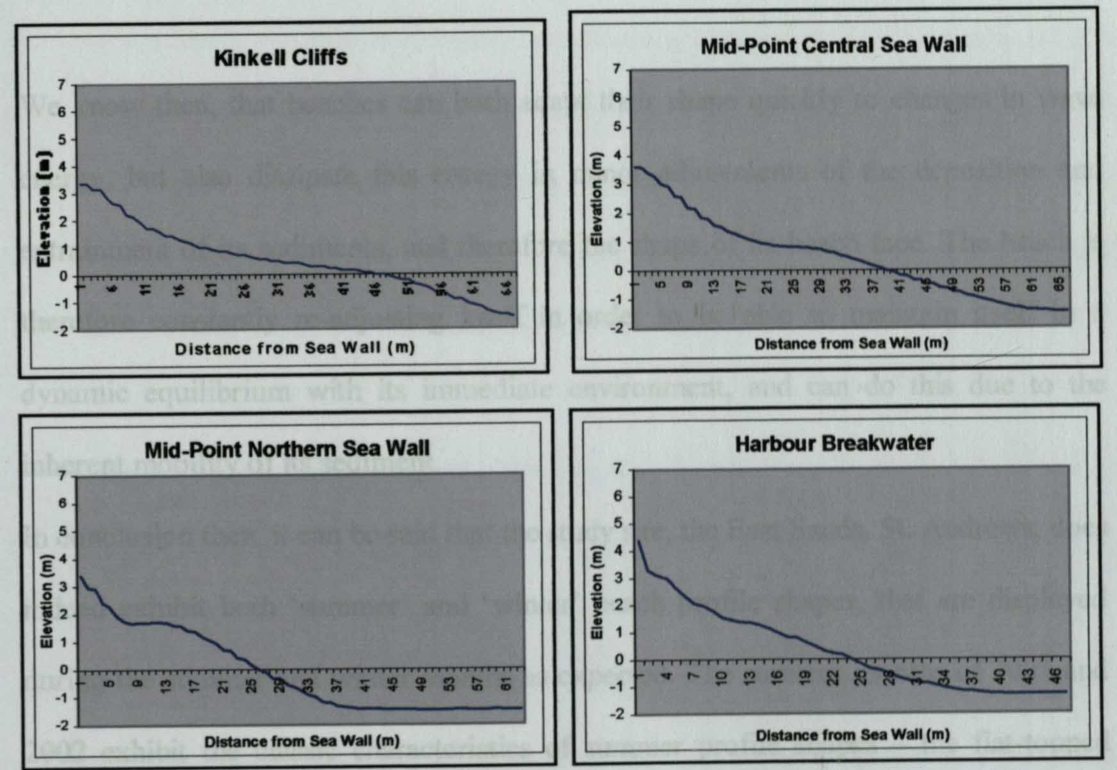


Figure 5.4.15: East Sands Profiles for February 2003

By February 2003, at Kinkell, the outer part of the profile had increased in gradient but now reaches the OD level 48m from the back wall. The profile had developed a concave steepening rising to 3.3m at the seawall. At the mid-point of the central wall the profile had risen slightly, the beach foot bar had become incorporated into the lower part of the beach face, above which the concave profile rose to 3.7m at the sea wall. The profile carried to OD level 40m from the back wall. The section measured from the mid-point of the northern wall showed considerable change from that of the preceding month. As before, there was no beach foot bar, but in place of the long, low gradient slope the profile now showed the presence of an upper beach terrace at about 1.8m and the surface rose sharply to 3.7m in the landward 5m. The profile extended 27m out from the sea wall. At the breakwater the profile sloped almost unfaultingly seawards, meeting the OD level 25m from the seawall. Only the steep uppermost 2m diverged from the flat profile, reaching the breakwater 4.5m above OD.

We know then, that beaches can both adapt their shape quickly to changes in wave energy, but also dissipate this energy in minor adjustments of the deposition and entrainment of its sediments, and therefore the shape of its beach face. The beach is therefore constantly re-adjusting itself in order to be able to maintain itself in a dynamic equilibrium with its immediate environment, and can do this due to the inherent mobility of its sediment.

In conclusion then, it can be said that the study site, the East Sands, St. Andrews, does indeed exhibit both 'summer' and 'winter' beach profile shapes, that are displayed during the summer and winter months as expected. The summer months of 2001 and 2002 exhibit the classic characteristics of summer profile shapes – the flat-topped berms, the wide back beaches, steep foreshores and greater volumes of sediment deposited on the beach face. While, in contrast, the winter profiles of both 2001 and 2002 also display classic characteristics of winter profile shapes – no berms, narrow back beaches and lower volumes of sediment deposited.

The profile shapes are concurrent with the prevailing weather conditions of both the summer and winter seasons i.e. the winter months experience more turbulent, sometimes stormy weather, resulting in shallower, reduced sediment volume profiles. While as the summer months experience gentler weather patterns, the beaches have more sediment deposited and an overall 'smoother' profile. And so, the shape of the beach, its gradient and the volumes of sediment deposited at any one time, constantly change in relation to the prevailing conditions, including seasonal storminess, of its immediate environment.

Chapter 6

Discussion and Conclusions

Fundamentally the primary reason for initiating this research was to determine the changes in beach profiles within the study site of the East Sands, St. Andrews. Not only to record and measure that change, but investigate the potential reasons for any modification and hopefully draw some conclusions about the processes that affect this particular part of the Scottish coastline today.

There is a wide ranging consensus that the shaping of all landforms is influenced by a range of morphogenic factors; including geology, tectonic movements, climatology and the wide range of coastal processes – waves, tides, sediment transport etc. Geology determines the pattern of rock outcrops on the coast, the sea floor and the hinterland, and the tectonic movements of the Earth's crusts result in uplift, titling, folding, faulting and subsidence of coastal rock formations. Climatic factors have influenced the wind and wave regimes that shape coastal features and the weathering processes that decay and disintegrate coastal rock outcrops. These coastal processes, that include the effects of rising and falling tides and associated tidal currents, are influenced by oceanographic factors such as sea temperature and sea salinity, are determined by climatology and the patterns of ocean currents.

Ancient coastlines, produced by past changes, continue to influence the evolution of existing coasts, and have to be considered in order to produce an all-encompassing approach to researching any coastal system. In addition, within modern historical times, the effects of various human activities also modify coastal evolution, both intentionally and unintentionally.

We know that coastal systems are dynamic, with identifiable inputs and outputs of energy and material, meaning that changes in input force coasts to respond in often dramatic ways and over a range of timescales - from short term fluctuations, over a few weeks or months, to long term changes over thousands of years. Variations in inputs cause direct changes in the immediate physical environment, for example, an increase in wave energy may enhance coastal erosion, or a decrease in nutrients may limit biological productivity. Thus all natural operations in a coastal environment are interlinked into a 'system', and the study of coasts is well suited to a systems approach. By treating a shoreline as a system, there is a need to investigate the response of the physical environment to its external forces, such as, wave energy, sea level change and human interference. By researching each set of system dynamics individually, it is possible to gain an intimate understanding of the inter-relationships within the coastal system.

Modelling of these system processes and shore evolution is of paramount importance for both the understanding of the controlling physical processes, and the solving of practical problems stipulated by coastal zone management. In recent years there has been a growing appreciation of the variation in the rate of coastal change, where formerly it had been held that the coasts developed more or less exclusively through the gradual (high frequency/low magnitude) action of the waves, tides and winds. However, many scientists now suggest that low frequency/high magnitude events, such as storms and tsunamis, may play dominant roles in the evolution of some coasts and ought to be considered as part of the system as much as any other function.

Alongside the challenge of investigating the scientific aspects of a coastal system, consideration must also be granted to those many users of the coastline, whose interests within a coastal context include economic activities, recreation, flood defence, water quality, nature conservation and conservation of the historical and archaeological heritage. Often these interests are conflicting, and managers frequently have to attempt a compromise or make hard decisions based on a prioritised course of action that reflects economic, political and legal constraints. Often, it has been found, the decisions are taken on the basis of a poor understanding of the functioning of the invariably complex coastal system under contemplation.

Therefore, fundamental to a successful management strategy is an adequate understanding of the basic physical, chemical, biological and human properties and processes which affect coasts, including their interactions and variability on different temporal and spatial scales. Much can be learned from the sedimentary and archaeological record about the way in which coasts have developed, and varied, in the past, and the way in which man has responded to or causes such changes, and with what consequences. This is the key of understanding the present, as an understanding of the causes and effects of past changes allow predictions of possible future changes to be made with greater confidence (Pye & Allen, 2000, Cooper at al, 2001).

Within the study site, several parameters have been investigated to paint a clearer picture of the entire system that is the East Sands, St. Andrews. The following parameters will be discussed individually: Beach Profile, Climatology, Coastal Engineering Works, The Rock Platform and Coastal Policies.

6.1 Beach Profile

In the coastal environment the prevailing conditions are never constant and continually change the beach topography, and so a long term 'profile of equilibrium' occurs at all times (Larson et al, 1999).

Any beach profile consists of two distinct sections, both with differing forces acting on them. The first a lower (submerged) part and the second an upper (lying above the mean water level) part, and it is the location of each portion that ultimately defines what forms and changes it. The morphodynamics of the lower, submerged portion of profile mostly depend on the action of wave induced oscillatory and transporting currents, whilst development of the upper part of the profile is mainly controlled by the 'run-up' or swash of the waves. This 'run-up flow' is essentially a relatively thin sheet of water moving back and forth along the beach profile. It tends to be high energy, which provides very active sediment transport leading to rapid morphological changes (Leont'yev, 1996).

This influence of the wave environment is fundamental to the shaping of the profiles at the East Sands. Waves are the primary force eroding, depositing and shaping in this environment. With a Mean Spring Tide Range of 4.5m – 4.8m (Ritchie, 1978) seawater reaches all parts of the East Sands at high tide, including the very back portion of the beach located right at the seawalls (Plates 6.1 & 6.2).

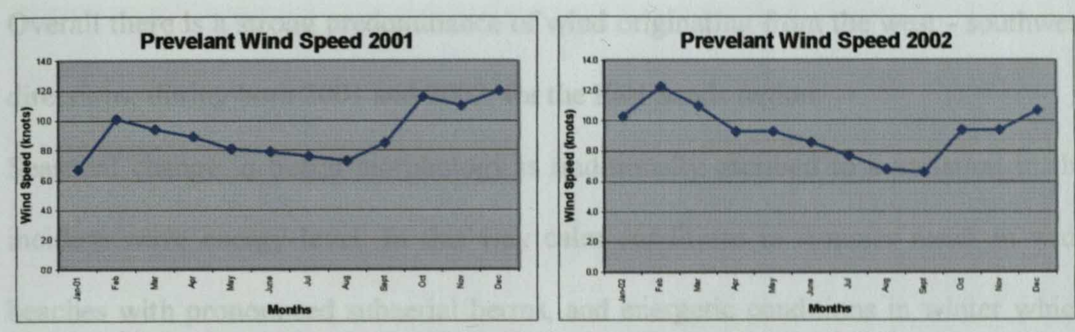
Plate 6.1: High Tide Wave Action **Plate 6.2: Waves Inundating the Central Seawall**

This means that no part of the beach remains untouched and that all sediment is open to the forces of sorting, entrainment and transportation. Indeed, looking at the volumes of sediment averaged by the Surfer v.7 programme, it is possible to gain an idea of the quantities of beach material that can be moved on and off the beach face. In general the volumes of sediment on the East Sands in the winter, is half of that present in the summer months. For example, the summer months of 2001 volumes present at between 400 – 700m³ compared with a winter value of 50 – 200m³. In 2002 the summer sediment volumes were 200 - 300m³, compared to the winter months, that experienced volumes between the 50 –100m³.

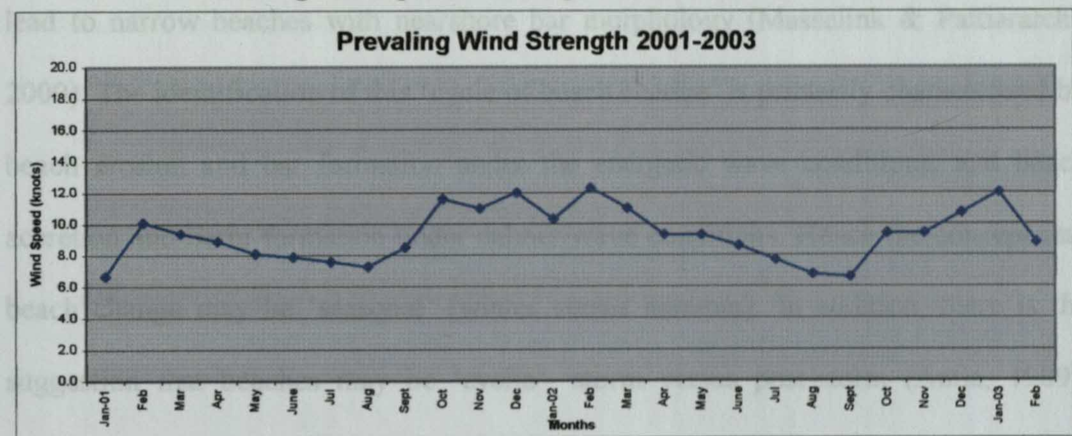
There is climatic evidence to support the idea that longshore velocities are greater in winter. This is a season in which the coast experiences high energy conditions resulting in greater entrainment and transport than at other times of the year.

This is principally the reason why beaches are 'bigger' in summer and 'smaller' in winter (Antia, 1989). The driving force behind this climatic seasonality is the prevailing wind strength and direction.

The weather records for the study site reveal that at the East Sands the monthly, average winds were higher in the winter (November-February) than in summer (May – September) (Figure 6.1).



Prevailing Wind Speed for the Separate Years of 2001 and 2002



Prevailing Wind Speeds for the Study Period
Figure 6.1: Prevailing Wind Speeds

The weather records support the theory from Antia (1989) that seasonal weather patterns will contribute to seasonal beach profile shapes. The prevalent wind directions recorded for the East Sands throughout the study period further compound this notion of seasonal behaviours (Figure 6.2).

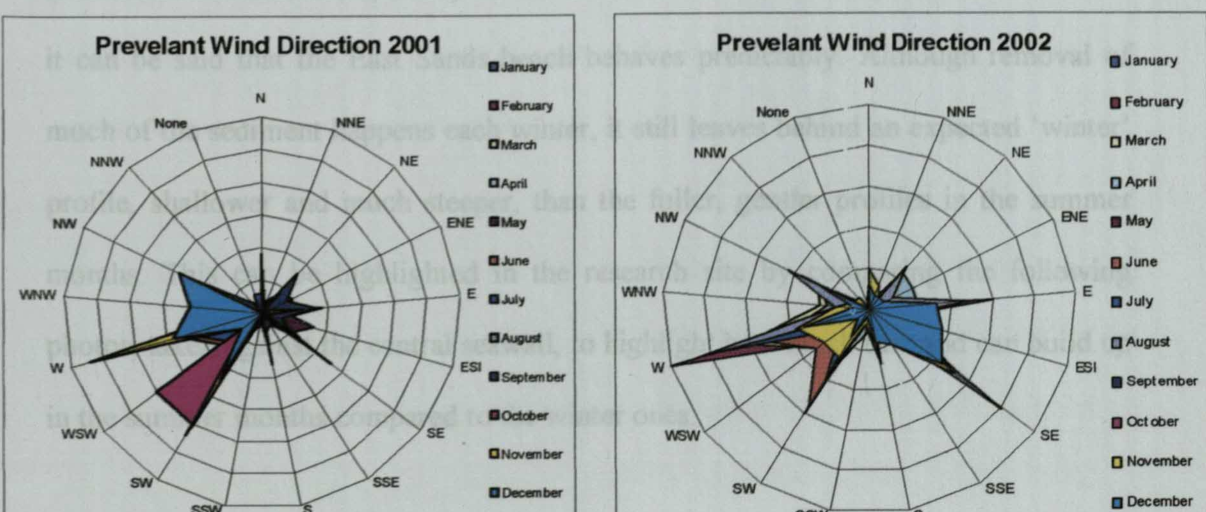


Figure 6.2: Prevailing Wind Direction for the East Sands 2001 & 2002

Overall there is a strong predominance of wind originating from the west - southwest directions, during both 2001 and 2002, for the East Sands region.

Seasonal change in beach morphology is traditionally ascribed to a variation in the incident wave energy level. In this way calm conditions in summer result in wide beaches with pronounced subaerial berms, and energetic conditions in winter which lead to narrow beaches with nearshore bar morphology (Masselink & Pattiaratchi, 2000). The identification of this 'cycle of beach change' is primarily characterised by beach erosion and bar formation under the energetic wave conditions, and beach accretion and berm formation under calmer wave conditions. Hence the concept that beach change may be 'seasonal' (winter versus summer). In addition, there is the suggestion that beaches may be 'cyclic'- storm versus post-storm (Antia, 1989). However, in both cases beach morphological change is primarily due to the variability in the incident wave height. On some coasts wave energy thresholds have been defined to predict the occurrence of beach erosion (and bar formation) and beach accretion (and berm formation) – however such thresholds are site specific and can not be readily applied outside a specific region for which they were defined (Masselink & Pattiaratchi, 2000). In the absence of local, formally defined thresholds it can be said that the East Sands beach behaves predictably. Although removal of much of the sediment happens each winter, it still leaves behind an expected 'winter' profile, shallower and much steeper, than the fuller, gentler profiles in the summer months. This can be highlighted in the research site by comparing the following photos, taken against the central seawall, to highlight how much the sand can build up in the summer months compared to the winter ones.

Plate 6.3: Lower Sand Level, Nov 2002

Plate 6.4: Higher Sand Level, June 2002

This response to seasonality means that, in theory and in practice, the profile moves between two extremes – gently sloping beaches with wide intertidal zones, with a longitudinal arrangement of ridges and runnels, or troughs, and steep beaches with narrow intertidal zones characterised by prominent berms, which are usually built up from the constructive action of waves. The construction of the summer profile involves the gradual migration of sandbars up the beach, under the influence of the low-amplitude waves evident during the summer months. In contrast the high-energy environment during the winter months causes the sediment built up through the summer months to become entrained and carried back into the offshore zone, where it serves to create offshore bars (Dean, 1991). The contour profiles taken at the East sands confirm that the level of the beach was much higher in the summer month of 2001 and 2002, when the greatest height of the beach face reached 7m, by contrast with some winter months where it fell to 1.5m above OD.

The elements of a breaking wave, and its steepness, is yet another indicator of variability in the coastal zone. Breaker type constitutes an incessant continuum for the beach, varying between spilling, plunging, collapsing and surging. Spilling breakers are less effective in entraining sediments than the more destructive plunging breakers (Antia, 1989). Surging breakers do as their name suggests and surge into coastal areas, often inundating them, meaning that they cover a larger area for possible entrainment, and again are more destructive than their counterpart, the collapsing breakers. Therefore, a beach dominated by plunging and surging breakers will experience more destructive activity than one dominated by spilling and collapsing breakers. In general, breakers are at their most destructive in the swash zone during Spring Tides in winter.

Plate 6.5: Surging Breakers, inundating right to the Central Seawall

The East Sands experiences both plunging at surging breakers during winter, and both the contour maps and volume computations serve to highlight the destructive nature of the prevailing wave environment. Plate 6.5 provides an illustration of surging breaker activity at the East Sand in November 2002.

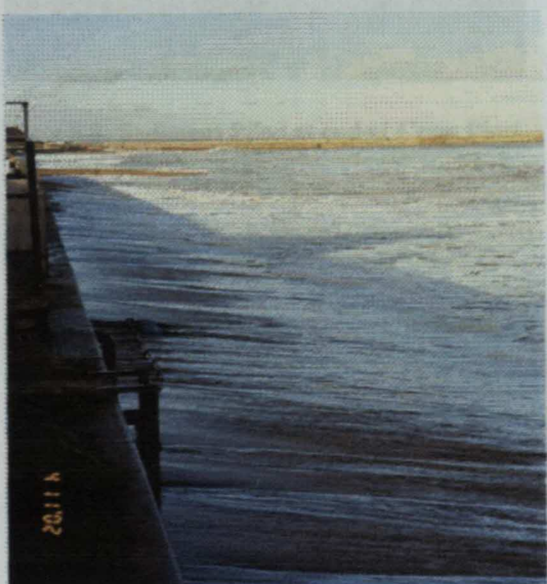


Plate 6.6: The Destructive Backwash of Surging Breaker Type

In Plate 6.6 surging breakers are seen to reach the backshore. Sediment transport is achieved by entrainment in the backwash, which impacts the whole of the upper beach. The sands are carried seaward of the breaker zone.

Breaking waves also play a part in the process of longshore sediment transport. Waves whose crests are inclined towards the shoreline results in the generation of the longshore current. At the case of the East Sands, longshore drift carries sediment towards the harbour throughout the year. The migration of sediment here is illustrated in Plates 6.7, 6.8 and 6.9.

Plate 6.7: Sediment Piled Between Cross Pier and Breakwater

Plate 6.8: Sediment Piled at end of Cross Pier/ Harbour Mouth

Plate 6.9: Lack of Sediment North of the Harbour

Plates 6.7, 6.8 and 6.9 demonstrate nicely this northerly movement of sediment within the East Sands coastal system. The Cross Pier and Breakwater were both constructed in an attempt to prevent the movement of sand, mud and silts from clogging up the both the inner and outer harbours.

The accumulation of sand between the two structures indicates that they are performing the function for which they were designed. Any sediment escaping from the East sands beach is carried clear of the harbour entrance, and there is no evidence of littoral sediment deposition immediately north of the harbour mouth, on the north side of the Long Pier (Plate 6.9).

We also know from previous research that there is no real seasonal variation in longshore current variation here, this is due to persistence of south-westerly winds (Antia, 1989) throughout the year within the study site.

Tides also play a part in the activity on any coastline. Their primary role is to alternately expose and submerge portions of the beach and the inner surf zone (Davies, 1985). During a tidal cycle the net result of this movement of sea level is to retard the rate at which sediment transport and changes in morphology take place. However the tide does more than just retard the surf zone processes; during a tidal cycle, the position of a swash zone, surf zone and shoaling wave zone is shifted with the tide both vertically and horizontally, causing the intertidal beach profile to be influenced to varying degrees by each of these processes every 12 hours (Masselink & Short, 1993).

In essence then, the wave environment and its characteristics are the dominant force in the surf zone, characterising the beach profile. Elements such as tides and longshore transport also play vital roles, as do factors such as wave energy and breaker form. Other variables such as grain size characteristics, swash period, ground water level, longshore current velocities are recognised as also exerting influence, but were not examined in this study.

It has been shown that the beach profiles at the East Sands do follow patterns of morphological change and it is inferred that they are strongly influenced by the wave activity, which is slight in summer and more violent in winter. The East Sands exhibits both 'summer' and 'winter' beach profiles.

6.2 Climatology

The prevailing climate plays a huge role in the shaping and changing of the beach profile at the East Sands, as it not only drives the waves that modify the coastline, but also provides the generating weather for those waves.

The study site is influenced by the wider climatology of the North Sea, and because of its geographical location, is subjected to variable, prevailing westerly winds. These extend roughly 2000-3000 km in breadth, making this area part of the belt of the temperate humid climate of the northern hemisphere. The dominance of westerly winds that transport air from the Ocean over the European seas produces a climate with a high rainfall but without extreme temperature variations.

Within this climatic region, the North Sea has a special character, in that it is classified as a 'transition' area i.e. the surrounding land prevents a pure oceanic climate from arising. This means that in all seasons the prevailing westerly winds convey the warming influence of the North Atlantic over the whole area and bring its waters into the North Sea, giving a maritime and exceedingly uniform condition i.e. a high average temperature and a small range for these latitudes.

During the winter, low pressure over the North Atlantic and northern parts of the North Sea, coupled with high pressure over Iberia and Continental Europe, creates a system of prevailing south-westerly winds over the North Sea. In summer a weakened depression in the North, coupled with deeper depressions over Europe, generate north-westerly prevailing winds (Goldberg, 1971). During the study period, the data collected confirmed the predominance of south-westerly winds, but only minor incidence of north-westerlies in the summer (Figure 6.2), however the data does confirm the activity of strong winds from the south-east, which are known to cause coastal erosion along the British North Sea coasts. There are induced depressions passing area in the southern part so fthe British isles, in winter, rather than following an expected path further north. Goldberg (1971) reported that average summer winds in the North Sea were Beaufort Force 3, but rose to Beaufort Force 5-6 in the winter, and correspondingly the average storm frequency increases from 1% in summer to 10-15% in winter.

The East Sands record showed summer winds averaging from 2-3, whereas in winter winds of Force 6-8 were common. The winter wind speeds are higher than those quoted by Goldberg (1971), this may be due to local topographic influences and the figures serve to confirm the reputation of St. Andrews Bay as being treacherous.

The Bay can be particularly turbulent through the winter months, often experiencing stormy conditions, sometimes for just a few hours, sometimes for a few days. Appendix 3 is a comprehensive collection of most Historical Storms to have affected not only the North Sea, but categorised to include those that would have particularly affected the St. Andrews coastline. The collection of local newspaper articles pertaining to the shipping disasters in the St. Andrews Bay area (Chapter 3), affords an insight into the stormy conditions that affected the coastline on what seems to be a regular, and frequent, occurrence. The information derived during the present study covers conditions encountered during only two years at the East sands. No exceptional conditions were experienced during this period.

Storm activity also has a profound effect on the morphology of a beach profile, as individual storms and post-storm recovery, of the profile, collectively determine the severity of the winter season. Also important is the duration of individual storms and their type. They may produce higher winds and greater storm surge but usually pass over an area quickly or, in contrast, less violent, slower moving storms may cause more damage by elevating water levels for several tidal cycles. The most major storm to hit the study site has to be the North Sea Storm Surge of 1953. Documented fully in Chapter 4, it was a catastrophic event that caused damage on most North Sea coastlines.

During the period of the study a storm in January-February 2002 led to a major loss of sands from the littoral zone. The severity of the erosion exceeded that of living memory and exposed bedrock and post-glacial deposits (Plate 6.10).

Plate 6.10: Bedrock Exposed Jan/Feb 2002

An essential feature of the climate of the North Sea is the variability, which is found in all seasons. Atlantic depressions, passing Scotland, bring about relatively large changes in all elements of weather, even within a few hours. Their conflicting air masses are the immediate cause of most of the storms, strong winds and rain, which are typical of the region in winter, but they can also occur in summer. It is also characteristic, too, that the highest temperatures of the coldest month are above or near the lowest temperatures of the warmest month (Goldberg, 1971). The East Sands alone has a highest average winter temperature at roughly 6/7°C, and the lowest average summer temperature at 5/6°C.

Gales, in the North Sea region, can occur from any direction in each month and they have their greatest frequency in winter (January) (Goldberg, 1971), an observation supported by the data from the East Sands, collected in both 2001 and 2002.

The North Sea distribution of air temperature tends to follow a trend also; January usually sees a maximum of 7°C and a minimum of 1°C, while in contrast, the highest July air temperature usually sees 17°C and lowest 12°C (Goldberg, 1971). Again the study site falls within this trend, January average highest and lowest temperatures for 2001 2002 have averaged out at 5°C and 0.9°C, and 8°C and 0.9°C respectively. While, average highest and lowest July temperature for 2001 and 2002, averaged out at 19°C and 11°C, and 18°C and 10°C respectively.

6.3 Coastal Engineering

The combination of modern day problems of rising sea level, large storm waves, coastal erosion and construction in or near the surf zone has heightened the awareness of environmental, engineering and planning problems at the shoreline. These problems arise when any shoreline retreat threatens housing, or other structures, and when seawalls, built to protect the threatened structures, begin to affect the surrounding natural environment (Plant & Griggs, 1992).

The presence of hard engineering coastal defence structures is very apparent at the East Sands. The East Sands had experienced erosion and inundation long before seawall construction began in 1950's/1960's, but only now are questions being asked whether the beach is suffering an adverse affects. The entirety of the 'back' of the beach terminates against three different sections of hard engineered sea wall defences. Most modern debate states that hard engineering ploys, that are largely unsympathetic to natural system processes, will either exacerbate the initial problem or 'carry' that problem elsewhere to attack another coastline in a different area. The research was undertaken partly to determine whether the coastal defence system at the East Sands inhibits or aggravates the destructive forces the beach might be experiencing.

There is also the breakwater that stretches offshore plus the Cross Pier built just inside the harbour mouth that primarily cause disturbance to the longshore sediment transport pattern of the study site. Unfortunately the limited duration of the research restricted in-depth studies of the erosion and recovery cycles beside these structures.

Immediately in front of a seawall the duration of the swash cycle decreases, but backwash velocities increase and backwash duration increases as wave reflection truncates the 'up-rush' portion of the swash cycle i.e. the front of the sea wall plays a significant role in beach stability (Plant & Griggs, 1992)

Beach profile changes in Monterey Bay, California, were used by Griggs et al (1994) to show there was no long-term effects of seawalls on adjacent beaches, no differences being detected between profiles of walled and non-walled beaches. Moody and Madsen (1995) concluded from their beach profile laboratory experiments To suggest these finding and demonstrate that it was only under extreme storm conditions that the fore dunes of non-walled beaches were severely, and permanently, eroded, whereas, the beach in front of a seawall was not permanently damaged.

Basco et al (1997) conducted a survey investigating the effects sea walls had on beaches in Virginia USA, and they concluded that erosion rates are not higher in front of the seawalls as originally thought, but seasonal sand volumes in front of the walls was greater than at non-walled locations. This suggested that winter waves carried more sand offshore in front of walls, but also that summer swell waves piled up more sand against walls in beach rebuilding. Previously highlighted in Section 6.1, they also found that walled beaches recover in about the same time as non-walled beaches for both seasonal transitions (winter to summer) and following erosional storm events. They believed that there are no adverse affects of seawalls on beaches where a steady supply of sediment exists. This may not be the case in a pocket beach off a major embayment such as St. Andrews Bay. In the absence of contrary evidence it is concluded that the seawall at the East Sands does not adversely affect the beach profile as a whole. The seawalls seem to be serving the purpose they were originally planned and built for – that of protecting the East Bents from erosion, and the immediate, low-lying coastal area from severe inundation. There could be a case that it is preventing some sediment from travelling on their natural northward drift, but sediment still exists in vast quantities at the town's next beach northwards – the West Sands – so if this was the case then it is likely to be of minor importance.

6.4 Sediment Budget

Waves are the most important agent of sediment transport in the beach zone (The Open University, 1978) so constant and regular supply of sediment, and a full sediment budget, to any beach ensures its ability to 'recover' itself if hit by any major storm events. The motion of seawater and sand mixing on the beach face provides the principal mechanism for sediment exchange between the subaqueous and subaerial zones of the beach, and hence shoreline change. The transport of sediment across a beach face is performed, both, by wave 'up-rush' and 'backwash'. Generally, the onshore flow velocities during the up-rush are larger but of shorter duration than the offshore velocities during the backwash. Maximum onshore velocities occur at the start of the up-rush, whereas maximum offshore velocities take place at the end of the backwash. The water depths that occur during the up-rush are generally larger than those that occur during the backwash (Masselink & Hughes, 1998) meaning that the process of waves breaking and running up and down the beach face, provides and interface between sand and water, which allows for entrainment and ultimately longshore transport. For this to happen successfully and a constant supply of sediment must be delivered to the beach in order to for this process to carry on, but without, seemingly, losing any sediment.

On high-energy beaches the most intense longshore transport normally takes place right in the surf zone, just shoreward of the wave breaking point. Under the combined action of the waves and the wave-induced currents, a relatively thin upper layer of sand is assumed to move along shore at some average advection speed over a lower layer, partly due to the acceleration from zero at the start of the backwash, and partly as percolation of water into the beach face decreases the volume of water returning seawards (Kraus, 1985). This means that the effective average depth to which sand is mixed by waves in the surf zone is in the range of 1-3% of the breaking wave height. A bimodal distribution of water and sediment is expected here, due to mechanical scouring and intense turbulence generated in the regions of breakers and colliding waves in the swash zone (Kraus, 1985).

Estimates can be made of the amounts of sediment moved by different agencies in the beach zone, and a budget is normally drawn up, of material that is imported (from rivers, or erosion of cliffs or old dunes) and that is exported (by longshore transport). Beach budgets can help quantify sediment transport cells in the coastal zone, ultimately meaning they can also help to evaluate the effects of different kinds of human activity in the beach zone e.g. the construction of a new harbour/breakwater (The Open University, 1978).

Patterns of shoreline erosion and deposition are often indicative of changes in the sedimentary budget along a particular stretch of coastline, in the presence of coastal change it is often useful to isolate the sources and sinks of sediments in the particular coastal circulation cell, as studies have shown that up-drift, offshore or inland changes, in sediment supply, have often quite distinct ramifications elsewhere on the coast. Sediment transport on beaches can be monitored by both direct and indirect measures, in the present case by surveying beach profiles so that zones of erosion and accumulation on the East Sands can be determined. A long record of observations would enable patterns of sediment transport and associated problems to be identified.

The main difference between summer and winter conditions is wave activity, and it is clear that sediment transport is the enhanced result of the combined effects of wave activity and modest tidal currents in the study area. Sediment volumes, during the research period, fluctuated from between 50m³ in the winter months, up to 700m³ in the summer. The data supports the deductions concerning the pattern of sediment transport in St. Andrews Bay, confirming that the area is a relatively low energy environment with generally low rates of sediment movement, but it should be remembered that observation and surveying were carried out on a monthly basis, and generally in calm conditions. It is entirely feasible that mass changes in profile and sediment budgets could have taken place between survey collection, as well as observed erosion, and accretion, may well be the result of site-specific parameters rather than part of the long term development of the area.

The long term studies of the areas have all concluded that development of the coastline suggests the offshore zone is the main source of sediment for the Sands, which is then is moved northwards towards the Harbour area and then Tentsmuir Point.

6.5 Rock Platform

It is necessary to consider whether the significant rock platform that bounds the south end of the study site hinders, or exacerbates, any processes in the shore zone of the East Sands itself.

The intertidal platform is well developed at St. Andrews, stretches south to Fife Ness, and varies in width from 50 – 500m at some points (Robertson & Miller, 1997). The rock platform continues offshore from the intertidal platform into water depths of some 15m at low tide, where it passes beneath recently laid down sediments Fugro, 1995). The platform is clearly increasingly buried by sand as you move towards the head of the St. Andrews Bay, lending credence to the theory of the northerly path of longshore transport.

The limited research on slowly changing rock coasts belies their significance as one of the world's most common elements of the littoral zone, and as an important source of sediment for both estuaries and beaches. Resistance to erosion due to such things as chemical composition, angle of dip, strike, bed thickness, joint pattern and density, degree of weathering etc, make changes on these coasts slow and difficult to determine, and so, the importance of these mechanisms varies with the climate and with the characteristics of the substrate (Trenhaile, 2002).

The research conducted by Trenhaile (2002) states that there is a direct relationship between platform width and tidal range, and an inverse relationship with the rate of submarine erosion, rock resistance, the degree of irregularity of the platform surface, the amount and persistence of the cliff foot debris and wave period. He also argues that the degree of influence a rock platform can have on both wave energy dissipation and longshore sediment transport is difficult to determine, so the potential influence the platform has on the East Sands is far from clear.

The rock platform east of Kinkell carries no littoral sediments and there is minimal erosion of the backing cliffs to supply fresh material. Nevertheless there is a constant supply of sediment for the beach all year round. There is therefore no evidence to show that although the rock platform is a major landform within the study site, it does not appear to exert any major bearing on the morphology or sediment transport at the East Sands.

6.6 Coastal Policy

In the U.K. Coastal Protection Policy has progressively moved away from the traditional re-active and parochial approach of providing localised hard-engineered coastal defence works, to solve what was often perceived to be a local problem with little consideration of wider effects. The present day approach adopts a more pro-active, long-term strategic assessment of shoreline management requirements and associated benefits and potential impacts, covering regional sediment sub-cells, or groups of adjacent sub-cells (Cooper et al, 1985). At present Fife Council manages the cleanliness of the actual beach, whilst various other bodies – St. Andrews University, St. Andrews Sailing Club, The St. Andrews Harbour Trust – all retain managing authority in various parts of the research site – the Gatty Marine land, the Clubhouse and immediate surrounding area, and the Harbour area respectively.

System dynamics, and the range of possible landform changes, must be allowed for when formalising shore management polices, as many coastal problems result from attempts to effectively forget and dismiss a particular shoreline configuration or habitat. The principal legislation governing coastal defence construction in Scotland is the ***1949 Coast Protection Act*** – mainly concerning coastal erosion – and the ***1961 Flood Protection (Scotland) Act.*** The latter Act was amended by the ***1997 Flood Prevention and Land Drainage (Scotland) Act.*** Both the 1949 and 1961 Acts give permissive powers to the relevant authorities, unlike in England where there is one major body – The Environment Agency, to oversee all planning, policy and legislature of the coastline.

The *1949 Coast Protection Act* empowers coast protection authorities, generally local authorities, to carry out coastal protection works to protect the land in their area. This system in Scotland has two important weaknesses; firstly, there is no strategic approach allowed for under current legislative structure for any single length of coast. Many different authorities – e.g. The Coast Protection Authority, MoD, Harbour/Port Authority, Railtrack and the Roads Authority – may all proceed with their own schemes without any consideration of the potential impacts on nearby parts of the coast. Secondly, the system also remains outside of ministerial control – i.e. there is no single body that provides a co-ordinating point for effective coastal management.

This meant that a review of planning procedures was granted and Scottish Authorities began the formalising of their own Strategic Coastal Management Plans (SMP) under guidance from the Scottish Office. Fife Council, under which the study site of the East Sands falls, to carry out their own SMP in 1998. The Council employed Posford Duvivier to carried out the surveys and assessment on their behalf, allowing detailed investigations to be carried out for the entirety of Fife's coastline, piecing together what processes were at work in each part of the coastline, and well as placing it in the context of the larger system that constitutes Scotland as a whole. In general the SMP process involves a move towards planning for strategic and sustainable long term coastal protection, which acknowledges the 'interconnectedness' of sections of coast at a variety of scales. This ensures the sustainability of coastal processes, landforms and habitats in the face of development pressure, as well as formation of an improved and uniformed recognition of the negative impacts on the natural heritage of flood and coast defence schemes and a common approach to their mitigation.

Fife Council's SMP concluded that the East Sands ought to be left alone, and that no further coastal engineering works were required to maintain the beach as it was.

Indeed the findings of this study coincide with the SMP conclusions, all data confirms that the East Sands remains a stable coastal environment, and does not experience any detrimental effects from the presence of the sea walls.

6.7 Conclusions

The coastal zone is the region of the earth that most humans have chosen to inhabit, and at the same time coastal areas are among the most dynamic in terms of physical processes. The interaction of humans living in coastal areas and this dynamic environment, where change can be sudden and devastating, has proven overtime to be difficult and potentially damaging.

This premise prompted this two-year investigation into beach profile change, in an attempt to better understand the coastal system as a whole at the East Sands, St. Andrews. The coastline at the East Sands is a revenue generating resource for the town, and realisation of this has prompted the governing body of Fife Council to try and to understand the changes that happen all round its coastline, in order to meet the demands of the growing population here, with the economic rewards that can be gained.

In order to make any suggestions of management strategy to address coastal problems, there was a need to investigate the workings of the coastal system in St. Andrews Bay. This was done primarily through examining the changes in beach profiles, as changes to this morphology are indicative of many processes at work in the local coastal zone.

Conclusions can be drawn on the following parameters; the beach sediments rest on sedimentary rocks of the Lower Carboniferous age, and historic records reveal that over the last 150 years the shoreline has remained stable at the East Sands, especially so since removal of sand was banned early in the 2oth century.

The coast is subjected to waves, tides, tidal currents and meteorological surges. The majority of waves are generated in deepwater and approach the study site from between 20°N and 60°N, although extreme waves greater than 4m can occur from all easterly sectors. Refracted waves from SE storms also access the East Sands, especially in winter so that a significant proportion of the total wave energy experience in this region derives from swell waves, whilst most of this swell is generated out in the Norwegian Sea; heavily diffracted swell from the Atlantic also contributes.

The longshore movement of sediment does not contribute to the sediment budget of the East Sands, where the cross-shore supply of sediment is to a large extent seasonal. Losses occurring during winter storms and gains through beach building in the summer months. The stability of the beach, at the East Sands, is controlled by the transfer of sand between offshore sinks, basins and the beach.

As a result of the research then, comprehensive assessment of the relationship between the wave energy and longshore transport generated in St. Andrews Bay, is fundamental for the efficient planning and management of this coastal zone. This is especially important in areas where the pressure from human activities (recreational, residential or industrial) has required alteration of the natural shore geometry, in this case the specific development of the harbour/East Bents area of the East Sands. Exploring the changes in beach profile at the East Sands has proven that, as a whole, this coastal system is relatively stable, and will remain so if contemporary coastal management polices remain sympathetic to its continual dynamism.

Beach profiling has revealed that systematic changes occur on the beach in response to seasonal changes and also to storm events, as expected from this seasonally affected coastline.

There is no evidence to suggest that the seawall has any deleterious impact, either in a short or long-term timeframe, on the beach itself.

Thus, the East Sands, as part of the larger North Sea Region experiences and exhibits all trends expected in this geographical area. The results collated highlights that the beach is responding as expected to storm activity – i.e. there is construction of a very distinct 'winter' profile morphology, when low volumes of sand are onshore, a narrow foreshore is present, with offshore bars and the small backshore berms.

The observations collected during the study confirm that the East Sands experiences regularity of storm activity, which helps with the seasonal formation of its 'winter' beach profile. Once during the surveys, severe storms at the East sands led to sufficient removal of sand to expose the underlying bedrock.

Under the circumstances of a larger study, recommendations for future work would be the investigation of such factors as the formation of scour troughs, beach lowering, end scour, up-coast accretion, down-coast erosion, far down coast shoals, reflection bars, delayed post-storm recovery, as well as a call for a more micro-scale investigation of how, if any, each section of sea wall affects the beach. There might be a possibility that they react as three separate entities rather then just one 'seawall' at the East Sands.

It is reasonable to assume, therefore, that the East Sands can, and will, remain a focal point in St. Andrews tourism plans as a recreational beach and historic harbour area, without undue pressures affecting the coastal processes occurring within this system.

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APPENDIX 1

Survey Data

Beach Profile Data Collection
12th March 2001

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351752.515	716313.018	4.331	351749.864	716401.889	1.353	351698.451	716551.972	2.437	351890.766	716198.696	0.026	352051.477	716055.881	-1.57
351751.718	716320.43	2.445	351760.293	716406.107	0.795	351714.48	716530.76	1.887	351870.188	716186.915	0.541	352054.81	716050.498	-1.56
351751.716	716320.438	2.455	351755.993	716429.921	0.735	351700.071	716524.25	2.411	351846.259	716171.512	1.348	352037.874	716072.052	-1.48
351755.836	716323.899	2.106	351740.353	716431.147	1.399	351690.316	716521.536	3.419	351830.072	716161.557	1.853	352022.868	716066.743	-1.04
351762.254	716325.117	2.069	351727.117	716430.204	1.98	351686.26	716520.668	4.052	351817.955	716155.284	2.401	352001.601	716059.342	-0.55
351771.627	716326.102	1.83	351717.186	716427.903	2.25	351689.657	716504.307	3.991	351814.201	716153.639	2.794	351976.741	716050.213	-0.2
351783.532	716330.763	1.216	351711.309	716425.762	2.743	351697.147	716503.933	2.846	351844.946	716143.531	1.692	351952.162	716039.962	0.011
351797.804	716335.058	0.804	351698.868	716466.912	3.241	351708.45	716502.631	2.244	351864.733	716140.948	1.223	351939.614	716033.929	0.532
351808.5	716340.256	0.496	351707.434	716468.583	2.363	351760.224	716460.162	0.469	351847.002	716126.427	1.778	351917.705	716024.042	1.213
351818.963	716344.456	0.449	351718.809	716470.604	1.952	351782.192	716444.766	0.56	351832.881	716119.74	2.33	351901.126	716015.507	1.706
351833.308	716351.045	0.259	351718.921	716470.637	1.956	351802.628	716411.639	0.396	351827.118	716117.614	2.805	351883.782	716006.597	2.447
351848.949	716358.784	0.04	351732.376	716473.452	1.507	351820.816	716374.067	0.35	351827.214	716117.668	2.812	351877.388	716003.133	3.253
351866.954	716366.757	-0.33	351750.343	716475.766	0.857	351839.592	716322.531	0.212	351840.223	716085.53	2.774	351910.702	715990.853	1.905
351884.343	716376.961	-0.75	351763.987	716478.41	0.553	351825.85	716308.282	0.572	351857.468	716092.929	1.915	351906.424	715968.56	2.558
351884.395	716377.018	-0.75	351778.517	716481.789	0.492	351813.259	716295.416	0.99	351879.851	716102.852	1.26	351906.192	715956.18	3.469
351902.913	716389.437	-1.21	351792.189	716484.683	0.214	351802.725	716284.825	1.571	351898.785	716111.35	0.544	351920.236	715938.331	3.4
351920.301	716398.226	-1.65	351807.748	716487.738	-0.13	351790.652	716272.148	1.966	351914.611	716118.233	-0.1	351927.266	715942.998	2.505
351920.367	716398.243	-1.66	351820.762	716490.362	-0.47	351779.95	716262.996	2.402	351941.729	716131.733	-0.56	351948.146	715955.525	1.678
351889.911	716411.421	-1.65	351834.229	716493.434	-0.97	351775.114	716259.961	3.016	351956.473	716138.629	-0.48	351965.112	715966.288	1.047
351876.679	716422.606	-1.69	351842.536	716496.191	-1.37	351783.599	716237.917	2.87	351978.882	716149.335	-0.92	351977.333	715973.896	0.667
351861.555	716418.847	-1.26	351852.044	716498.955	-1.84	351792.218	716241.204	2.199	351998.566	716156.984	-1.34	351991.069	715984.164	0.239
351846.268	716414.658	-0.71	351847.705	716520.601	-1.38	351807.029	716247.258	1.774	352013.107	716162.068	-1.86	352006.915	715994.267	-0.13
351827.849	716407.999	-0.13	351863.897	716545.16	-1.27	351826.812	716256.105	1.134	352010.933	716170.063	-1.95	352030.545	716010.357	-0.6
351811.503	716401.87	0.309	351845.832	716553.988	-0.97	351850.394	716267.048	0.49	352013.204	716142.574	-1.75	352049.672	716023.378	-1.16
351797.87	716396.919	0.569	351833.686	716577.081	-0.9	351880.395	716277.091	-0.08	352001.026	716137.222	-1.24	352064.944	716033.065	-1.72
351784.409	716391.231	0.753	351829.845	716601.194	-1.04	351904.055	716288.531	-0.44	351984.147	716130.756	-0.81	352076.46	716018.722	-1.73
351771.49	716384.974	0.815	351811.989	716584.044	-0.65	351904.141	716288.566	-0.43	351967.639	716121.631	-0.78	352064.676	715997.923	-1.06
351761.228	716380.572	1.155	351805.465	716572.54	-0.39	351921.071	716297.441	-0.62	351975.624	716098.429	-0.47	352049.604	715967.45	-0.32
351748.842	716375.397	1.903	351788.811	716571.985	0.06	351943.42	716309.082	-1.02	351990.861	716105.655	-0.67	352042.115	715951.278	-0.05
351740.236	716371.703	2.175	351768.901	716571.836	0.309	351957.064	716316.262	-1.4	351983.321	716114.775	-0.64	352037.777	715940.973	0.121
351734.213	716368.002	2.053	351750.307	716573.298	0.601	351970.586	716322.211	-1.91	351999.221	716112.823	-0.97	352023.918	715926.333	0.61
351729.505	716394.714	2.227	351712.005	716575.49	1.915	351989.818	716259.763	-1.7	352020.005	716107.48	-1.51	352016.333	715908.476	1.063
351729.809	716394.618	2.236	351697.151	716576.044	2.543	351970.709	716244.012	-1.11	352022.34	716101.134	-1.48	351984.251	715911.477	1.695
351731.704	716395.384	2.191	351685.664	716576.428	3.024	351946.725	716229.907	-0.64	352026.809	716093.605	-1.48	351973.399	715900.745	2.241
351740.779	716398.338	1.88	351679.182	716577.76	3.034	351919.519	716213.518	-0.33	352040.803	716078.739	-1.69	351968.935	715892.066	2.86

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H	V	D
351968.962	715892.031	2.881
352003.465	715880.376	2.312
352000.798	715873.902	3.192
352029.96	715868.947	2.05
352046.251	715855.674	2.837
352052.412	715866.5	1.804
352061.8	715880.069	1.223
352070.201	715900.999	0.649
352083.788	715913.252	0.203
352091.214	715920.254	-0.16
352097.933	715927.52	-0.07
352107.957	715942.532	-0.45
352118.315	715956.551	-0.92
352124.401	715965.86	-1.44
352058.841	716043.368	-1.64
351952.122	716095.749	-0.48
351919.254	716080.779	0.018
351909.991	716104.793	0.098
351890.622	716121.564	0.689
351871.303	716148.712	0.928
351872.215	716193.915	0.262
351845.243	716202.137	1.119
351825.533	716199.786	1.641
351812.315	716196.046	2.032
351803.34	716192.644	2.513
351800.455	716191.678	2.874
351792.937	716224.156	2.523
351772.729	716273.241	2.619

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351684.253	716569.129	3.221	351745.912	716438.839	0.94	351787.411	716239.527	2.591	351988.506	716134.562	-1.06	352029.306	716060.175	-1.15
351678.755	716577.913	3.208	351765.189	716427.561	0.621	351796.364	716242.975	1.847	352002.331	716138.177	-1.6	352055.21	716018.361	-1.14
351686.519	716575.673	2.813	351737.999	716409.728	1.72	351806.601	716247.268	1.76	352008.251	716139.917	-1.86	352072.175	716011.075	-1.37
351697.959	716574.536	2.424	351723.737	716392.718	2.727	351830.278	716254.021	0.854	352020.146	716107.217	-1.77	352083.887	716011.429	-1.69
351715.567	716573.16	1.88	351736.243	716397.041	1.928	351858.047	716260.665	0.432	352022.592	716101.177	-1.72	352071.91	715988.204	-0.92
351733.505	716572.201	1.32	351749.864	716400.604	1.31	351887.693	716269.006	0.078	352027.019	716093.888	-1.71	352057.627	715963.405	-0.31
351750.681	716571.844	0.791	351774.152	716406.3	0.612	351916.29	716274.825	-0.39	352031.366	716097.301	-1.91	352047.903	715947.984	-0.04
351765.061	716572.318	0.619	351797.401	716411.194	0.368	351929.904	716278.426	-0.6	352022.516	716085.794	-1.44	352036.219	715929.586	0.369
351781.685	716573.265	0.337	351817.477	716415.947	0.105	351945.984	716282.902	-1.2	352009.624	716076.276	-0.96	352030.821	715920.445	0.64
351804.705	716574.405	-0.29	351830.046	716419.078	0.073	351953.525	716283.248	-1.5	351989.107	716062.416	-0.52	352024.599	715911.474	0.987
351825.045	716571.537	-0.88	351845.396	716422.854	-0.38	351959.878	716282.671	-1.8	351973.031	716053.035	-0.26	352018.514	715904.79	1.085
351849.601	716569.704	-1.4	351865.493	716428.327	-1.21	351976.087	716277.841	-2.06	351954.596	716042.501	0.068	351990.606	715908.496	1.506
351878.915	716568.562	-1.72	351890.957	716436.367	-1.86	351975.683	716233.323	-2.05	351934.562	716032.714	0.637	351978.233	715895.798	2.292
351902.646	716566.792	-1.82	351913.992	716441.959	-1.93	351961.193	716223.969	-1.13	351914.096	716023.383	1.172	352003.225	715880.491	2.346
351924.991	716563.991	-1.81	351930.854	716446.116	-1.93	351943.977	716216.041	-0.61	351901.765	716017.299	1.646	352000.793	715873.874	3.072
351943.273	716554.015	-1.98	351951.402	716446.824	-2.03	351921.076	716203.561	-0.12	351891.202	716011.438	1.921	352025.876	715867.943	2.377
351935.732	716527.065	-1.81	351947.742	716398.25	-2.12	351894.417	716189.625	0.14	351883.212	716006.804	2.616	352047.545	715854.987	2.854
351968.395	716493.543	-1.88	351921.633	716392.036	-1.8	351872.566	716180.318	0.226	351877.335	716003.229	3.116	352052.013	715860.904	2.339
351939.105	716491.278	-1.81	351902.809	716385.465	-1.32	351859.809	716174.118	0.62	351889.551	715999.184	2.544	352058.135	715872.72	1.462
351929.947	716492.141	-1.9	351888.009	716379.485	-0.74	351844.197	716167.101	1.396	351904.527	715992.575	1.838	352070.006	715892.919	0.867
351922.003	716492.174	-1.98	351862.516	716368.346	-0.17	351831.817	716161.661	2.14	351906.481	715973.808	2.531	352084.091	715912.058	0.262
351896.19	716494.537	-1.99	351842.211	716357.676	0.139	351821.635	716156.984	2.212	351904.359	715963.947	3.098	352094.242	715927.48	-0.18
351872.132	716492.094	-1.95	351823.003	716349.412	0.221	351814.233	716153.642	3.118	351903.101	715958.873	3.571	352100.662	715938.579	-0.38
351856.219	716488.668	-1.54	351806.779	716343.023	0.55	351825.561	716138.431	2.458	351920.19	715938.291	3.37	352112.584	715950.681	-0.61
351837.901	716485.768	-0.68	351789.427	716334.271	1.027	351840.72	716120.052	2.317	351926.542	715943.973	2.603	352119.729	715959.347	-0.92
351815.697	716483.671	-0.12	351773.904	716325.716	1.564	351840.648	716096.252	2.522	351942.975	715956.118	1.628	352127.419	715970.613	-1.49
351799.555	716482.118	0.22	351762.569	716318.905	2.153	351839.377	716085.187	3.084	351970.321	715974.695	0.798	352096.326	715969.031	-0.88
351777.465	716478.48	0.183	351757.465	716315.358	2.645	351846.159	716087.825	2.407	351995.025	715993.054	0.094	352050.75	716003.017	-0.82
351756.529	716476.852	0.503	351754.09	716313.765	2.998	351859.001	716092.729	2.075	352019.048	716011.171	-0.45	352017.299	716050.644	-0.77
351735.951	716474.669	1.146	351769.179	716305.158	2.185	351877.394	716100.296	1.036	352034.762	716023.027	-0.78	351996.232	716086.46	-0.73
351716.381	716471.253	1.89	351781.74	716301.977	1.754	351892.689	716107.087	0.388	352053.589	716035.863	-1.31	351981.716	716113.19	-0.67
351705.538	716468.637	2.475	351801.283	716295.786	1.125	351908.637	716111.682	0.01	352063.57	716040.636	-1.67	351954.384	716121.752	-0.27
351699.11	716466.944	3.036	351792.226	716278.998	1.776	351923.221	716117.323	-0.23	352059.249	716043.334	-1.57	351929.876	716154.212	0.013
351714.363	716454.863	2.062	351784.135	716264.308	2.245	351932.038	716119.555	-0.18	352055.008	716050.077	-1.55	351929.865	716154.248	0.007
351730.484	716446.707	1.536	351777.201	716253.995	3.086	351953.115	716124.76	-0.25	352051.304	716055.765	-1.56	351916.737	716184.152	0.07
351745.9	716439.008	1.004	351783.174	716237.899	3.121	351971.042	716130.006	-0.56	352040.467	716078.217	-1.72	351891.892	716228.19	0.2

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H	*V*	*D*
351863.899	716260.357	0.374
351840.095	716298.956	0.611
351817.208	716346.167	0.325
351806.964	716380.775	0.417
351787.278	716439.76	0.306
351762.948	716494.941	0.197
351746.203	716503.173	0.493
351726.33	716515.381	1.481
351707.762	716521.762	2.055
351699.81	716522.099	2.557
351689.238	716521.395	3.513
351686.201	716520.658	4.093

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351751.602	716314.335	4.341	351692.177	716574.816	2.648	351712.199	716423.509	2.758	351783.549	716256.143	2.556	351864.803	716143.289	0.557
351754.39	716316.03	2.854	351701.315	716574.334	2.381	351719.868	716404.191	2.71	351783.311	716237.917	3.089	351855.417	716128.609	1.419
351754.411	716316.223	2.908	351704.393	716574.305	2.377	351724.01	716392.713	2.74	351791.399	716240.839	2.452	351848.207	716119.717	2.57
351754.509	716316.23	2.745	351716.436	716573.149	1.89	351731.89	716395.397	2.665	351798.938	716243.977	2.519	351838.439	716110.78	2.411
351754.508	716316.232	2.734	351725.567	716573.016	1.609	351739.502	716398.078	1.886	351806.681	716247.171	1.668	351832.201	716104.443	3.118
351761.244	716327.655	2.607	351739.619	716572.427	1.093	351746.732	716400.504	1.304	351815.884	716250.897	1.208	351839.744	716085.154	3.043
351751.687	716350.713	2.49	351754.508	716571.795	0.76	351763.314	716405.783	0.706	351833.02	716256.888	0.764	351845.14	716087.101	2.483
351751.41	716351.045	2.529	351769.343	716572.054	0.588	351780.245	716411.036	0.595	351849.757	716263.259	0.559	351854.895	716091.447	2.423
351743.099	716371.297	2.552	351783.244	716572.343	0.284	351796.052	716415.205	0.365	351871.054	716271.931	0.295	351859.164	716093.622	2.382
351731.383	716398.085	2.613	351797.306	716572.123	0.031	351809.157	716419.463	0.537	351887.676	716278.448	0.068	351868.212	716098.076	1.353
351738.951	716413.39	1.387	351812.627	716572.437	-0.49	351820.85	716423.067	0.282	351904.013	716283.16	-0.2	351886.858	716106.255	0.515
351732.939	716429.167	1.443	351825.891	716572.371	-0.99	351833.272	716426.138	0	351916.854	716285.428	-0.34	351905.216	716112.883	0.05
351720.473	716432.747	2.472	351838.899	716572.126	-1.28	351846.928	716430.626	-0.7	351930.892	716288.112	-0.76	351918.314	716120.662	-0.17
351714.943	716453.969	2.545	351840.557	716542.396	-1.3	351857.745	716433.482	-1.2	351943.359	716291.226	-1.4	351927.474	716123.623	0.015
351723.3	716462.622	1.522	351871.725	716503.704	-1.79	351871.538	716437.128	-1.68	351948.374	716292.321	-1.6	351942.757	716129.668	-0.09
351721.429	716484.028	1.62	351851.862	716500.397	-1.5	351875.315	716437.92	-1.79	351940.982	716273.911	-1.02	351950.84	716133.042	-0.15
351709.183	716488.871	2.401	351837.158	716498.401	-1.07	351909.874	716400.702	-1.77	351927.155	716264.86	-0.42	351964.163	716136.738	-0.39
351697.007	716492.236	3.052	351826.47	716496.889	-0.68	351898.806	716394.152	-1.43	351912.496	716256.014	-0.03	351977.623	716140.583	-0.86
351691.386	716493.166	3.949	351813.36	716493.913	-0.05	351884.388	716385.739	-0.81	351922.237	716233.895	-0.08	351989.335	716144.53	-1.31
351688.778	716509.367	4.02	351801.997	716491.866	0.375	351863.924	716375.026	-0.11	351942.139	716231.123	-0.6	351996.822	716146.29	-1.52
351698.445	716512.812	2.757	351786.826	716489.153	0.427	351839.755	716362.222	0.221	351966.625	716226.152	-1.55	351987.623	716124.129	-0.99
351705.705	716516.868	2.339	351780.03	716487.83	0.283	351822.251	716353.05	0.394	351951.768	716217.769	-0.78	351979.876	716114.89	-0.63
351710.546	716518.247	2.212	351785.283	716472.133	0.349	351804.558	716343.692	0.546	351932.771	716209.28	-0.15	351979.766	716114.8	-0.62
351721.518	716521.097	1.634	351797.603	716469.946	0.327	351789.461	716335.371	0.867	351923.151	716205.391	-0.04	351971.434	716102.439	-0.26
351720.523	716540.107	1.677	351809.43	716471.462	0.243	351778.51	716328.952	1.26	351900.044	716197.369	0.124	351996.619	716097.911	-0.91
351707.944	716544.321	2.088	351822.265	716474.429	-0.14	351774.129	716326.452	1.389	351875.404	716178.999	0.058	352021.042	716095.199	-1.56
351705.138	716544.448	2.45	351778.279	716458.102	0.375	351769.101	716323.321	2.07	351859.965	716174.148	0.352	352005.21	716081.143	-0.88
351692.858	716545.789	2.885	351763.136	716480.69	0.321	351763.409	716320.001	2.544	351847.963	716168.562	0.903	351988.799	716067.801	-0.4
351684.37	716546.813	3.667	351745.333	716478.229	0.686	351754.021	716314.133	3.053	351839.502	716164.871	1.358	351965.17	716051.956	-0.1
351680.939	716546.755	4.011	351732.353	716475.658	1.156	351761.063	716295.422	3.119	351833.183	716162.064	2.19	351942.847	716040.145	0.263
351684.369	716562.791	3.439	351722.699	716473.073	1.533	351775.664	716297.985	2.508	351830.002	716160.739	2.643	351927.898	716032.295	0.765
351683.073	716572.087	3.316	351713.988	716471.267	2.257	351786.413	716300.737	1.447	351819.873	716156.129	2.488	351909.946	716021.726	1.338
351677.917	716578.831	3.842	351704.408	716468.765	2.627	351796.798	716280.157	1.374	351814.37	716153.666	3.133	351896.558	716014.258	1.77
351677.971	716578.83	3.847	351699.156	716467.183	3.081	351788.914	716275.477	2.189	351822.717	716149.377	2.48	351891.622	716011.648	2.385
351679.081	716577.384	3.234	351702.198	716456.88	2.979	351785.375	716273.984	2.449	351833.647	716148.803	2.701	351883.846	716007.104	2.594
			351706.975	716437.302	2.894	351771.819	716268.555	3.049	351845.904	716146.691	1.497	351877.252	716003.01	3.194

Beach Profile Data Collection

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H	V	D
351898.517	715995.03	2.548
351913.198	715972.191	2.516
351907.677	715953.876	3.465
351920.283	715938.339	3.385
351926.589	715943.231	2.627
351932.601	715947.964	2.331
351937.541	715951.131	1.785
351957.592	715967.29	1.119
351972.535	715979.226	0.699
351993.183	715995.128	0.073
352013.793	716011.389	-0.38
352029.885	716023.463	-0.65
352042.19	716031.972	-0.95
352054.314	716039.76	-1.4
352057.332	716041.795	-1.53
352072.277	716013.701	-1.46
352084.295	716001.937	-1.48
352072.206	715982.195	-0.72
352056.134	715958.153	-0.22
352045.461	715942.002	0.079
352036.273	715928.531	0.443
352027.788	715918.589	0.754
352019.944	715906.768	1.105
351987.606	715913.236	1.532
351978.64	715903.368	1.911
351974.8	715897.575	2.468
351972.36	715890.224	2.907
352003.985	715880.764	2.34
352000.959	715873.868	3.078
352022.759	715867.946	2.478
352046.001	715855.051	2.99
352048.599	715860.947	2.496
352052.842	715868.702	1.592
352060.082	715881.648	1.185
352068.009	715897.717	0.782
352075.675	715912.438	0.382

H	V	D
352087.919	715912.517	0.175
352096.362	715921.179	0.01
352103.311	715925.846	-0.11
352114.193	715943.396	-0.54
352121.426	715955.763	-0.85
352126.931	715965.951	-1.3
352128.216	715968.887	-1.47
352064.875	715991.411	-0.78
352035.411	716013.479	-0.63
351984.576	716040.689	-0.3
351950.711	716060.708	-0.03
351923.006	716086.039	0.136
351894.866	716112.317	0.292
351840.178	716187.113	0.991
351824.974	716205.264	1.348
351806.678	716221.439	2.414
351769.839	716273.744	2.924

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351679.13	716537.746	5.902	352056.024	715875.3	1.334	351866.344	716064.27	2.262	351949.981	716191.883	-0.65	351975.515	716285.155	-2.05
351815.455	716133.872	7.623	352061.295	715884.679	1.021	351860.76	716062.291	2.497	351935.392	716187.728	-0.25	351994.491	716289.496	-2.18
351920.234	715938.185	3.367	352069.568	715895.333	0.766	351857.006	716060.98	2.7	351920.507	716184.432	0.066	351981.333	716351.394	-2.13
351924.628	715941.317	2.887	352074.978	715901.355	0.623	351852.912	716059.641	2.665	351905.101	716180.788	-0.02	351964.957	716350.401	-1.99
351927.739	715943.989	2.814	352082.643	715914.073	0.26	351850.104	716058.484	3.165	351889.333	716174.049	0.135	351933.745	716355.597	-1.87
351933.099	715948.118	2.301	352089.027	715925.922	-0.07	351840.548	716082.106	3.087	351872.881	716168.936	0.101	351918.977	716354.791	-1.25
351941.498	715955.06	1.643	352100.809	715937.487	-0.35	351843.984	716083.755	2.63	351859.288	716166.438	0.398	351898.283	716352.922	-0.58
351953.981	715963.639	1.289	352107.806	715946.516	-0.4	351849.377	716085.43	2.886	351844.943	716163.342	1.237	351880.907	716349.995	-0.25
351965.122	715971.311	0.937	352115.863	715960.073	-0.84	351852.187	716086.373	2.698	351835.531	716161.111	1.767	351864.348	716346.572	0.009
351978.196	715980.77	0.417	352122.801	715974.338	-1.39	351861.268	716089.393	2.05	351827.786	716158.539	2.642	351845.381	716342.564	0.288
351992.549	715991.391	0.011	352129.834	715986.051	-1.82	351873.529	716093.546	1.485	351824.815	716157.513	3.012	351826.175	716339.673	0.506
352007.383	716005.586	-0.2	352136.585	716001.421	-2.24	351884.526	716097.291	0.874	351817.688	716155.018	2.868	351814.72	716336.949	0.269
352026.667	716019.851	-0.61	352096.638	716000.201	-1.64	351889.9	716099.035	0.441	351814.26	716153.678	3.147	351814.664	716336.962	0.261
352042.094	716029.771	-0.98	352071.716	716011.576	-1.39	351901.346	716103.002	0.211	351829.078	716178.695	1.696	351803.28	716336.857	0.387
352057.434	716040	-1.44	352058.389	716026.508	-1.3	351911.732	716106.911	0.026	351821.94	716180.988	2.39	351790.979	716332.325	0.62
352070.975	716048.154	-1.91	352048.05	716041.539	-1.26	351915.387	716108.758	0.164	351817.549	716181.16	2.774	351781.568	716328.116	0.92
352084.064	716055.085	-2.24	352053.402	716083.628	-2.24	351930.113	716113.138	0.198	351821.71	716208.514	1.52	351776.407	716325.67	1.083
352098.937	716033.688	-2.33	352041.994	716078.095	-1.84	351945.515	716118.26	-0.04	351811.515	716206.539	2.633	351765.124	716319.417	2.379
352090.734	716022.342	-2.09	352024.718	716071.023	-1.28	351963.59	716124.102	-0.46	351807.118	716205.104	2.9	351760.775	716316.424	3.257
352080.968	716006.221	-1.5	352001.641	716061.293	-0.64	351979.531	716129.405	-0.82	351798.88	716202.734	2.895	351755.847	716314.345	3.162
352071.338	715992.104	-0.98	351982.665	716053.32	-0.22	351991.829	716134.124	-1.18	351796.729	716202.105	3.034	351753.929	716313.695	3.064
352060.873	715976.224	-0.49	351961.703	716043.559	0.017	352001.737	716137.288	-1.67	351792.517	716220.488	2.892	351765.675	716283.847	3.053
352049.826	715958.884	-0.22	351943.621	716035.48	0.207	352011.099	716141.688	-2.15	351783.192	716237.828	3.041	351773.686	716288.083	2.861
352041.6	715944.523	0.115	351924.203	716027.096	0.974	351997.418	716124.711	-1.31	351790.011	716239.971	2.927	351778.477	716291.2	2.649
352035.698	715935.659	0.435	351906.8	716019.013	1.483	351983.85	716115.369	-0.83	351794.19	716241.019	3.086	351785.79	716295.135	1.769
352027.589	715922.235	0.693	351898.979	716015.143	1.897	351982.712	716115.535	-0.27	351798.776	716242.959	2.693	351795.363	716300.696	1.023
352023.212	715914.139	1.075	351889.536	716009.961	2.344	351972.635	716107.231	-0.54	351810.501	716245.988	1.475	351774.056	716356.106	0.78
352017.841	715904.587	1.315	351883.868	716006.721	2.747	351959.447	716095.967	-0.2	351824.108	716249.325	0.674	351788.533	716363.221	0.478
352011.675	715895.169	1.414	351879.356	716004.299	2.996	351944.451	716078.762	-0.22	351834.723	716252.096	0.449	351797.744	716365.835	0.752
352004.447	715881.614	2.252	351877.075	716002.93	3.191	351953.266	716118.049	-0.2	351849.73	716255.681	0.593	351803.762	716368.642	0.706
352002.552	715877.614	2.708	351863.948	716028.079	3.197	351967.486	716145.078	-0.68	351872.292	716260.636	0.401	351784.387	716377.418	0.741
352000.861	715873.798	3.076	351868.377	716030.909	2.69	351980.536	716163.925	-1.22	351893.005	716265.483	0.154	351779.921	716375.667	0.533
352019.193	715867.724	2.652	351874.579	716034.25	2.779	351991.539	716177.373	-2.39	351914.11	716269.235	-0.27	351768.892	716370.464	0.745
352046.992	715854.685	2.905	351880.562	716037.327	2.287	351991.522	716177.366	-2.39	351929.645	716272.758	-0.66	351761.958	716367.751	0.989
352049.863	715859.697	2.333	351889.953	716042.632	1.714	351984.214	716199.356	-1.8	351943.314	716276.212	-1.13	351754.137	716365.086	1.764
352052.312	715866.092	1.793	351877.59	716066.201	1.831	351970.028	716196.391	-1.14	351954.453	716279.132	-1.64	351745.513	716361.829	2.767

H	V	D	H	V	D	H	V	D
351738.927	716359.168	2.97	351733.141	716491.078	0.722	351700.846	716546.836	2.949
351737.268	716358.732	3.042	351767.993	716515.563	0.618			
351733.474	716382.09	3.216	351762.109	716522.06	0.223			
351723.614	716392.616	2.993	351747.775	716526.78	0.48			
351729.787	716395.003	3.099	351735.356	716530.354	0.988			
351737.842	716397.865	2.051	351720.47	716533.989	1.517			
351749.848	716401.655	0.968	351707.86	716535.383	2.018			
351761.256	716405.025	0.647	351702.61	716535.551	2.774			
351766.872	716407.109	0.519	351699.78	716535.805	2.943			
351779.427	716411.188	0.77	351694.145	716536.053	2.894			
351800.346	716417.409	0.578	351686.273	716536.553	3.613			
351815.614	716422.392	0.235	351683.849	716536.897	3.939			
351830.744	716426.947	-0.09	351682.94	716558.61	3.566			
351846.677	716431.786	-0.64	351677.934	716578.73	3.831			
351862.623	716435.461	-1.31	351678.652	716577.761	3.228			
351879.024	716440.659	-1.95	351687.404	716575.952	2.742			
351880.913	716489.189	-2.02	351695.813	716575.268	2.701			
351856.599	716489.822	-1.67	351700.847	716575.06	2.726			
351840.051	716491.103	-1.14	351713.445	716574.184	1.958			
351823.388	716490.782	-0.51	351734.889	716573.241	1.163			
351807.674	716488.703	-0.01	351750.549	716572.5	0.875			
351791.328	716486.728	0.308	351766.365	716572.173	0.692			
351774.374	716483.164	0.666	351775.013	716572.087	0.52			
351756.581	716479.675	0.362	351782.275	716572.028	0.459			
351744.341	716478.21	0.477	351799.313	716572.667	-0.17			
351731.123	716475.267	0.853	351819.406	716572.949	-0.94			
351717.335	716471.405	1.728	351831.259	716572.599	-1.25			
351710.915	716470.047	2.431	351810.855	716551.699	-0.61			
351703.097	716468.038	3.001	351797.203	716546.153	-0.02			
351698.782	716466.867	3.061	351784.109	716535.082	0.314			
351693.144	716483.675	3.811	351768.839	716532.383	0.468			
351694.755	716485.098	3.386	351764.37	716531.998	0.191			
351698.609	716485.512	2.926	351755.601	716534.045	0.358			
351705.465	716486.654	2.605	351742.786	716536.124	0.889			
351713.499	716487.685	1.765	351724.853	716541.289	1.409			
351723.84	716489.012	1.117	351704.457	716546.701	2.483			

28th August 2001

H	V	D	H	V	D	H	V	D
351678.768	716539.153	8.116	351847.31	716260.383	2.726	352000.88	715873.76	5.254
351678.193	716579.191	5.928	351857.901	716264.736	2.597	352003.681	715877.883	4.72
351678.845	716577.714	5.265	256340.959	664697.236	17.59	352005.604	715880.779	4.278
351686.397	716576.87	5.037	351814.302	716153.756	5.719	352046.079	715855.554	4.946
351693.114	716576.782	4.884	351823.83	716157.159	4.99	352047.749	715859.716	4.603
351702.656	716576.132	4.463	351830.757	716159.532	4.374	352051.111	715866.765	3.837
351713.894	716574.685	4.025	351837.241	716162.058	3.851	352054.982	715873.544	3.492
351724.806	716573.926	3.576	351844.122	716165.119	3.144	352020.827	715903.847	3.26
351738.306	716573.711	3.15	351848.871	716167.517	2.791	352024.061	715908.823	3.189
351751.735	716573.26	2.877	351852.986	716169.415	2.563	352027.659	715913.515	3.084
351756.719	716573.367	2.79	351839.563	716085.2	5.445	352032.715	715919.418	2.692
351699.06	716467.007	5.435	351847.255	716088.246	5.121			
351706.794	716468.222	4.589	351853.878	716090.467	4.381			
351713.532	716469.747	4.175	351857.696	716092.01	4.336			
351720.142	716471.302	3.761	351863.457	716094.128	3.979			
351728.532	716472.798	3.042	351869.862	716096.455	3.549			
351733.537	716473.374	2.9	351876.443	716098.984	2.867			
351723.632	716392.502	5.804	351881.893	716100.434	2.677			
351731.229	716395.178	4.767	351877.139	716002.994	5.428			
351739.204	716397.857	4.01	351882.929	716006.334	4.884			
351747.768	716400.848	3.148	351888.219	716009.17	4.423			
351751.459	716402.134	3.012	351894.294	716012.353	4.128			
351753.88	716313.664	5.806	351903.111	716017.089	3.797			
351761.591	716316.492	5.023	351908.966	716020.947	3.566			
351767.366	716318.309	4.298	351913.913	716023.873	3.668			
351774.067	716320.67	3.623	351919.038	716026.797	3.055			
351778.433	716322.09	3.06	351929.061	716031.825	2.548			
351782.023	716322.986	2.999	351920.127	715938.161	5.555			
351783.544	716237.856	5.605	351925.511	715942.497	4.864			
351791.852	716240.898	5.335	351930.035	715946.444	4.322			
351798.642	716243.232	4.441	351937.505	715952.178	4.02			
351804.884	716245.263	4.027	351946.837	715959.255	3.706			
351812.459	716247.37	3.611	351953.915	715964.354	3.514			
351818.389	716249.667	2.906	351960.712	715969.886	3.244			
351828.877	716253.136	2.729	351970.829	715978.602	2.677			
351838.615	716256.849	2.711	351974.515	715981.613	2.469			

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
349380.209	719679.125	7.078	351887.729	716509.656	-5.01	351856.186	716264.091	0.7	351877.242	716003.169	3.322	352052.372	715852.758	3.025
349387.578	719638.244	5.77	351723.856	716392.57	3.14	351873.417	716270.382	0.376	351886.061	716008.375	2.681	352057.408	715864.31	1.907
351678.849	716576.775	3.262	351732.26	716395.339	2.324	351891.517	716276.156	0.129	351896.113	716013.929	2.23	352062.151	715871.368	1.43
351692.193	716576.659	2.852	351741.519	716398.229	1.768	351902.166	716279.082	-0	351908.019	716020.228	1.484	352024.445	715899.701	1.449
351707.186	716576.621	2.148	351748.01	716400.537	1.09	351915.233	716283.151	-0.4	351921.134	716026.234	0.973	352033.768	715908.396	1.05
351718.628	716576.611	1.681	351759.435	716404.578	0.86	351926.496	716285.812	-0.8	351929.228	716029.723	0.572	352044.623	715918.967	0.573
351731.829	716576.561	1.294	351770.782	716407.727	0.974	351940.623	716289.313	-1.33	351940.304	716034.465	0.331	352035.889	715940.582	0.2
351744.838	716576.745	0.982	351785.681	716412.126	0.825	351946.207	716290.722	-1.66	351951.591	716039.529	0.154	352045.768	715952.019	-0.02
351758.251	716577.268	0.583	351798.955	716415.645	0.679	351814.428	716153.716	3.759	351964.423	716045.216	-0.04	352058.341	715964.571	-0.26
351769.776	716577.147	0.306	351812.209	716419.105	0.397	351822.846	716156.506	2.799	351976.944	716051.461	-0.32	352073.614	715978.754	-0.76
351782.491	716577.88	0.126	351822.552	716421.995	0.099	351832.024	716160.187	2.17	351989.978	716057.907	-0.54	352088.347	715991.864	-1.31
351782.472	716577.883	0.125	351837.217	716426.475	-0.43	351841.148	716163.998	1.542	352002.016	716062.985	-0.81	352100.898	716000.329	-1.77
351796.612	716579.157	-0.093	351847.606	716429.617	-0.84	351850.859	716168.171	0.576	352013.62	716068.392	-1.08	352114.142	716008.511	-2.11
351805.48	716580.251	-0.492	351858.906	716433.132	-1.43	351858.345	716171.06	0.401	352023.714	716073.962	-1.47	352125.532	716015.673	-2.49
351817.8	716581.62	-0.967	351870.701	716436.077	-1.94	351893.701	716179.762	0.192	352033.85	716079.508	-1.83	351825.231	716568.752	-1.15
351829.47	716582.509	-1.205	351880.176	716437.789	-2.13	351904.944	716184.912	0.297	352043.511	716084.946	-2.41	351804.516	716571.103	-0.48
351699.275	716466.827	3.105	351754.015	716313.633	3.673	351918.777	716191.02	0.163	351920.311	715938.265	3.404	351787.12	716572.628	0.206
351699.274	716466.825	3.112	351761.795	716316.338	2.603	351934.517	716197.383	-0.21	351927.822	715943.414	2.544	351772.636	716576.555	0.243
351706.765	716468.452	2.389	351771.572	716319.271	1.951	351947.123	716201.441	-0.61	351936.368	715950.05	2.053	351754.649	716576.313	0.721
351714.806	716470.028	2.021	351781.865	716323.226	0.884	351965.352	716206.967	-1.23	351946.451	715957.048	1.728	351737.79	716576.377	1.137
351720.75	716471.168	1.662	351790.44	716326.21	0.713	351977.129	716210.808	-1.85	351954.916	715962.602	1.452	351719.636	716576.467	1.653
351726.774	716472.151	1.026	351795.465	716327.837	0.635	351988.879	716213.001	-2.42	351962.642	715967.562	1.056	351706.8	716576.462	2.152
351733.808	716473.266	0.785	351808.001	716331.89	0.779	351839.597	716085.09	3.616	351973.879	715974.459	0.392	351692.706	716576.546	2.825
351743.994	716474.083	0.53	351824.138	716336.42	0.619	351852.914	716090.297	2.581	351983.747	715981.228	0.213	351678.37	716576.251	3.302
351752.04	716474.592	0.893	351837.369	716339.803	0.461	351866.872	716096.251	1.906	351995.729	715988.495	0.105			
351766.044	716476.932	0.858	351853.674	716343.121	0.248	351875.362	716100.64	1.399	352007.563	715995.459	-0.07			
351779.487	716479.891	0.656	351867.828	716346.486	0.008	351881.656	716103.475	0.545	352017.366	716000.685	-0.27			
351792.847	716482.841	0.299	351882.647	716350.013	-0.29	351895.623	716109.971	0.57	352032.046	716008.291	-0.57			
351798.442	716484.931	-3.018	351898.607	716353.566	-0.69	351907.021	716114.522	0.481	352046.479	716016.138	-0.95			
351811.336	716488.775	-3.377	351907.072	716355.469	-1.03	351921.217	716120.192	0.278	352056.795	716022.154	-1.24			
351823.952	716492.638	-3.917	351916.869	716357.292	-1.53	351936.53	716125.354	0.063	352068.004	716029	-1.59			
351834.82	716495.533	-4.391	351783.423	716237.765	3.755	351951.788	716130.647	-0.18	352081.059	716038.088	-2.14			
351848.901	716499.341	-4.586	351796.605	716242.525	2.469	351964.324	716134.694	-0.46	352092.346	716043.46	-2.34			
351859.023	716500.497	-4.697	351809.92	716247.799	1.726	351978.194	716138.767	-0.92	352104.066	716049.589	-2.51			
351871.435	716503.906	-4.904	351820.339	716252.083	1.105	351990.271	716142.715	-1.35	352001.064	715873.951	3.07			
351883.228	716508.337	-4.833	351840.224	716258.67	0.876	352003.731	716148.461	-2.03	352005.97	715880.801	2.209			

H	V	D	H	D	V	H	V	D	H	V	D	H	V	D
351676.895	716537.931	6.393	351740.594	716475.005	1.167	351761.038	716315.607	2.683	351875.434	716270.502	0.293	351898.523	716107.997	0.552
351676.893	716537.932	6.395	351747.532	716476.369	1.073	351767.775	716317.332	2.317	351882.284	716271.434	0.252	351904.931	716110.532	0.486
351676.895	716537.934	6.398	351754.197	716477.696	0.945	351774.617	716319.253	2.013	351889.322	716272.456	0.287	351911.779	716112.77	0.341
351676.895	716537.935	6.401	351760.866	716479.161	0.821	351781.305	716321.445	1.602	351896.86	716273.563	0.127	351918.253	716114.953	0.294
351676.895	716537.935	6.405	351767.563	716480.364	0.693	351787.831	716323.22	1.085	351903.641	716274.345	-0.06	351924.372	716117.831	0.152
351676.893	716537.935	6.403	351774.496	716481.224	0.567	351795.545	716324.893	0.993	351910.529	716275.293	-0.25	351930.092	716118.457	0.14
351676.893	716537.931	6.397	351781.515	716481.776	0.446	351802.617	716325.963	0.941	351917.798	716276.556	-0.51	351936.913	716119.599	0.024
351676.893	716537.931	6.398	351788.471	716482.257	0.32	351809.827	716326.906	0.867	351925.773	716277.914	-0.73	351944.395	716120.877	-0.15
351676.894	716537.933	6.397	351795.712	716483.036	0.197	351816.887	716327.827	0.765	351814.163	716153.638	3.64	351950.588	716121.785	-0.23
351677.941	716578.733	3.859	351802.714	716483.914	0	351823.88	716328.958	0.658	351820.45	716155.669	2.781	351958.233	716123.039	-0.43
351678.672	716577.923	3.079	351809.611	716484.509	-0.18	351830.993	716330.142	0.545	351826.894	716157.593	2.295	351876.99	716002.889	3.418
351686.847	716577.421	3.028	351816.244	716485.016	-0.37	351837.917	716331.152	0.434	351833.244	716159.821	2.053	351883.057	716006.044	2.687
351694.593	716577.343	2.792	351823.093	716485.266	-0.55	351844.934	716331.888	0.334	351839.987	716161.963	1.679	351888.974	716008.785	2.358
351702.158	716577.117	2.487	351830.01	716485.682	-0.76	351852.093	716332.413	0.232	351846.36	716163.929	1.19	351894.972	716011.302	2.112
351710.131	716576.823	2.163	351839.804	716486.636	-1.2	351859.665	716333.01	0.052	351853.018	716165.929	0.556	351901.167	716013.909	1.894
351717.526	716576.528	1.844	351723.546	716392.524	3.608	351868.306	716332.653	-0.04	351861.67	716168.577	0.303	351907.487	716016.699	1.661
351724.806	716576.441	1.454	351730.47	716394.882	2.637	351874.98	716333.189	-0.13	351869.903	716171.218	0.098	351913.855	716019.919	1.404
351732.1	716576.277	1.112	351736.881	716397.108	2.23	351881.595	716333.864	-0.21	351871.878	716179.812	0.325	351920.074	716023.023	1.131
351739.289	716576.094	0.899	351743.453	716399.427	1.783	351888.315	716334.886	-0.4	351880.352	716181.696	0.483	351925.982	716026.218	0.769
351746.261	716576.04	0.649	351750.129	716401.467	1.25	351894.646	716336.132	-0.45	351887.547	716182.844	0.447	351931.566	716028.92	0.584
351753.455	716575.648	0.483	351757.857	716402.992	1.23	351901.163	716337.432	-0.62	351895.058	716184.127	0.352	351937.945	716031.541	0.402
351763.092	716574.858	0.264	351765.119	716404.255	1.227	351908.089	716338.993	-0.83	351903.287	716185.376	0.198	351944.469	716033.93	0.268
351770.45	716573.906	0.301	351772.272	716405.308	1.14	351783.246	716237.805	3.947	351911.008	716186.335	0.061	351950.635	716036.713	0.165
351777.613	716573.295	0.301	351779.564	716406.73	1.001	351789.7	716240.15	2.935	351918.466	716187.19	0.045	351957.068	716039.293	0.1
351784.864	716572.851	0.239	351786.487	716408.308	0.842	351795.978	716242.619	2.365	351925.468	716187.72	-0.06	351963.545	716041.696	-0.01
351792.078	716572.718	0.048	351793.292	716409.582	0.693	351802.156	716244.891	2.083	351930.917	716188.11	-0.2	351969.781	716043.681	-0.07
351799.742	716572.632	-0.21	351800.995	716411.081	0.516	351808.628	716247.412	1.767	351939.433	716189.353	-0.4	351976.237	716045.774	-0.19
351806.617	716572.503	-0.51	351808.064	716412.517	0.389	351815.634	716250.516	1.237	351839.44	716085.141	3.734	351982.682	716047.89	-0.32
351813.642	716572.118	-0.84	351815.688	716414.354	0.306	351822.484	716253.543	0.931	351846.081	716087.376	2.712	351989.29	716050.341	-0.46
351820.529	716571.38	-1.04	351822.63	716415.843	0.155	351828.54	716256.289	0.86	351852.024	716089.605	2.331	351920.138	715938.256	3.388
351698.862	716466.984	3.322	351828.895	716416.928	-0.04	351834.901	716259.159	0.837	351858.337	716091.967	2.127	351926.288	715942.887	2.693
351705.981	716468.769	2.561	351835.66	716418.271	-0.25	351841.534	716261.561	0.794	351864.836	716094.434	1.896	351931.84	715946.734	2.346
351712.675	716470.435	2.2	351842.4	716419.636	-0.48	351848.219	716264.136	0.711	351872.253	716097.423	1.541	351937.521	715950.613	2.086
351719.371	716471.861	1.844	351849.24	716420.861	-0.68	351854.923	716265.98	0.63	351878.708	716100.309	1.202	351943.185	715954.414	1.899
351726.002	716472.944	1.192	351856.661	716422.227	-0.93	351861.742	716267.672	0.512	351885.484	716103.014	0.86	351949.073	715958.05	1.695
351733.818	716473.83	1.169	351753.889	716313.783	3.599	351868.492	716269.302	0.4	351891.97	716105.629	0.638	351955.327	715962.409	1.47

Beach Profile Data Collection
11th October 2001

H	V	D
351960.909	715966.133	1.237
351966.582	715969.878	0.94
351972.557	715973.763	0.667
351978.176	715977.508	0.438
351984.12	715980.942	0.324
351989.99	715984.377	0.234
351995.876	715987.875	0.152
352001.798	715991.732	0.053
352007.582	715995.36	-0.05
352013.271	715998.808	-0.19
352019.998	716003.023	-0.34
352000.829	715873.804	3.018
352005.316	715880.482	2.352
352045.791	715854.893	3.122
352048.754	715860.862	2.364
352051.897	715866.179	1.808
352055.367	715871.607	1.538

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351761.78	716259.281	5.89	351748.296	716573.45	0.766	351765.898	716448.542	0.978	351776.571	716323.876	1.332	351899.69	716284.208	-0.16
351767.641	716285.455	3.371	351757.456	716572.851	0.705	351754.126	716433.719	1.014	351779.459	716325.745	1.169	351905.83	716285.435	-0.41
351765.142	716302.866	3.154	351766.543	716572.883	0.547	351743.741	716421.063	1.428	351782.451	716326.842	1.211	351909.994	716286.363	-0.58
351763.372	716321.366	2.628	351774.001	716572.832	0.367	351734.034	716416.193	1.862	351788.703	716330.244	0.898	351899.284	716269.553	0.013
351759.049	716342.339	2.104	351781.384	716572.885	0.176	351724.748	716408.989	2.968	351792.513	716331.861	0.897	351887.404	716255.916	0.335
351759.016	716342.353	2.105	351789.021	716572.374	-0.12	351723.307	716392.536	3.679	351802.727	716336.05	1.058	351878.922	716245.636	0.424
351748.31	716369.453	2.066	351795.874	716571.804	-0.41	351728.128	716394.456	3.144	351812.499	716340.808	0.952	351866.464	716228.627	0.695
351748.008	716385.991	1.814	351803.443	716571.298	-0.73	351732.678	716396.442	2.703	351824.277	716347.544	0.743	351857.327	716215.001	0.881
351737.473	716415.736	1.765	351807.5	716571.02	-0.92	351737.949	716398.504	2.015	351833.425	716353.722	0.496	351847.496	716200.441	0.873
351730.347	716440.144	1.739	351790.321	716553.989	-0.1	351747.989	716402.398	1.566	351843.47	716360.08	0.268	351836.72	716194.719	1.143
351730.188	716487.891	1.151	351773.055	716539.832	0.567	351759.388	716406.535	1.144	351852.504	716366.02	-0.03	351825.633	716190.323	1.79
351721.272	716493.976	1.482	351760.599	716529.338	0.852	351769.461	716409.823	0.889	351857.903	716369.453	-0.25	351818.318	716187.261	2.589
351711.894	716498.505	1.925	351746.455	716515.533	0.931	351777.694	716411.362	0.801	351864.618	716374.023	-0.6	351813.344	716185.318	3.017
351706.886	716501.842	2.414	351735.131	716502.314	0.954	351777.71	716411.379	0.798	351854.85	716353.667	0.1	351807.649	716182.299	3.394
351706.858	716501.868	2.409	351726.736	716493.808	1.167	351787.042	716412.966	0.818	351840.911	716335.317	0.587	351804.36	716180.72	4
351702.912	716504.601	2.768	351714.926	716482.63	1.924	351795.222	716414.496	0.733	351831.912	716324.629	0.782	351814.089	716153.654	3.822
351697.38	716507.983	2.999	351698.913	716466.913	3.384	351805.039	716417.27	0.521	351821.644	716310.807	0.826	351819.213	716156.132	3.23
351693.134	716510.427	3.202	351703.329	716467.721	3.123	351812.469	716419.923	0.381	351811.854	716297.753	0.708	351822.949	716157.816	3.142
351688.886	716512.757	3.754	351708.093	716468.743	2.931	351822.173	716423.354	-0.09	351805.11	716290.476	0.831	351829.28	716160.819	2.41
351684.968	716531.612	3.777	351713.595	716470.028	2.326	351829.802	716426.253	-0.45	351796.162	716281.199	1.509	351837.357	716163.97	1.569
351689.411	716536.645	3.259	351720.903	716472.149	1.711	351835.002	716428.337	-0.66	351789.283	716274.522	2.192	351844.489	716167.451	0.937
351694.177	716553.141	2.868	351729.284	716474.302	1.221	351818.449	716405.855	0.358	351783.046	716268.366	2.851	351853.607	716171.567	0.586
351683.929	716566.37	3.524	351738.541	716476.861	0.968	351807.7	716393.214	0.687	351777.988	716262.717	3.377	351860.594	716174.952	0.779
351677.892	716578.989	3.876	351746.076	716478.206	1.035	351796.885	716379.862	0.974	351774.919	716260.071	3.919	351874.407	716182.113	0.824
351678.469	716577.368	3.34	351751.529	716479.091	1.07	351786.463	716367.7	1.088	351783.12	716237.768	3.976	351884.49	716187.067	0.785
351682.825	716576.966	3.294	351759.539	716480.924	1.068	351777.753	716362.341	0.962	351787.627	716239.945	3.328	351895.41	716192.069	0.543
351687.897	716576.712	3.034	351767.928	716482.224	0.908	351768.576	716357.298	1.315	351792.425	716242.247	2.942	351905.203	716196.736	0.277
351691.79	716576.246	2.769	351777.269	716484.631	0.699	351760.013	716352.094	1.73	351798.941	716245.341	2.486	351914.817	716202.095	0.017
351696.099	716575.781	2.65	351785.751	716486.677	0.528	351754.38	716348.795	2.34	351807.556	716249.455	1.775	351922.281	716205.545	-0.17
351699.121	716575.145	2.549	351793.604	716488.41	0.331	351749.902	716346.485	2.91	351818.488	716254.086	1.266	351929.454	716208.47	-0.44
351703.018	716574.665	2.059	351802.634	716490.59	-0.1	351745.555	716344.259	3.347	351830.354	716258.999	0.847	351922.24	716195.31	-0.03
351710.727	716574.384	1.747	351811.962	716493.09	-0.53	351743.201	716343.146	3.661	351842.294	716264.169	0.559	351910.924	716181.447	0.268
351718.789	716574.114	1.418	351816.326	716494.138	-0.77	351753.904	716313.619	3.711	351855.559	716269.866	0.489	351902.892	716171.936	0.543
351726.729	716574.113	1.105	351798.467	716478.206	0.245	351758.775	716315.413	3.219	351868.468	716274.133	0.318	351892.345	716160.427	0.708
351734.24	716573.904	0.859	351786.536	716469.083	0.599	351764.892	716318.174	2.614	351880.267	716278.724	0.14	351883.035	716150.056	0.665
351742.196	716574.077	0.719	351774.781	716458.29	0.901	351770.783	716320.836	1.921	351889.781	716281.66	0.116	351871.517	716145.724	0.349

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351860.913	716137.621	0.698	351901.034	716018.283	1.815	352004.705	716009.67	-0.18	352036.12	715866.056	2.43	351869.944	716072.223	2.004
351852.331	716133.002	1.425	351911.794	716024.245	1.448	352009.358	716012.802	-0.24	352038.555	715861.449	2.703	351859.781	716075.144	2.603
351844.933	716128.23	2.19	351923.25	716030.006	0.95	352006.766	715997.629	-0.1	352040.784	715856.717	3.045	351848.159	716081.136	3.064
351838.06	716122.374	3.015	351932.769	716036.139	0.591	352001.672	715988.406	0.076	352051.983	715852.902	3.004	351842.61	716077.253	3.825
351832.065	716116.502	3.218	351942.132	716040.584	0.379	351997.864	715980.862	0.261	352052.94	715857.483	2.71	351833.806	716128.814	2.745
351828.258	716114.738	3.596	351948.669	716044.099	0.237	351993.866	715971.449	0.483	352054.161	715863.74	2.027	351833.81	716128.94	2.731
351839.416	716085.116	3.766	351955.602	716047.948	0.206	351990.037	715959.346	0.759	352057.586	715871.288	1.574	351829.686	716141.082	3.136
351844.336	716087.063	3.159	351963.387	716051.946	0.209	351984.931	715948.937	1.066	352062.453	715879.096	1.299	351817.891	716172.506	3.089
351850.16	716088.931	2.855	351970.795	716056.094	0.048	351979.925	715937.742	1.435	352064.384	715887.622	1.028	351820.02	716204.227	1.836
351858.513	716092.299	2.31	351978.106	716059.669	-0.12	351976.346	715926.763	1.678	352067.221	715891.494	1.013	351812.24	716211.851	2.373
351871.014	716097.624	1.438	351981.514	716061.325	-0.21	351972.631	715919.297	1.922	352071.127	715897.473	0.95	351804.2	716220.78	2.793
351883.026	716102.97	0.962	351981.523	716061.372	-0.23	351968.663	715913.09	2.123	352074.742	715902.921	0.76	351795.943	716232.94	2.971
351896.264	716109.391	0.566	351985.699	716064.338	-0.35	351965.794	715909.556	2.651	352080.984	715913.263	0.56	351784.305	716254.762	3.028
351905.406	716114.525	0.404	351974.403	716045.895	0.055	351962.63	715904.793	2.891	352084.95	715920.958	0.244	351784.3	716254.767	3.035
351911.201	716117.424	0.435	351967.178	716036.128	0.065	351960.664	715901.327	3.044	352087.382	715926.768	0.074			
351919.633	716120.415	0.525	351956.995	716019.689	0.308	351959.031	715898.816	3.167	352090.305	715930.995	-0.05			
351931.724	716124.948	0.322	351945.701	716003.032	0.768	351971.914	715895.334	2.86	352070.68	715930.272	0.036			
351944.331	716129.395	0.02	351935.218	715987.878	1.344	351989.091	715885.448	2.548	352042.004	715943.377	0.164			
351952.651	716132.567	-0.13	351925.5	715975.366	1.762	352000.753	715873.913	3.12	352020.087	715947.014	0.487			
351959.057	716135.06	-0.38	351916.111	715971.349	1.97	352002.379	715877.008	2.748	352002.917	715945.673	0.813			
351947.734	716115.69	0.053	351912.392	715968.791	2.53	352007.07	715884.479	2.201	351986.391	715944.723	1.105			
351940.145	716105.915	0.272	351909.319	715966.266	2.941	352015.412	715895.771	1.628	351975.525	715942.929	1.386			
351932.842	716098.006	0.182	351905.695	715962.801	3.19	352021.089	715903.505	1.391	351962.784	715940.325	1.645			
351917.513	716081.9	0.469	351902.966	715959.974	3.546	352025.988	715910.602	1.206	351965.263	715967.681	1.024			
351907.637	716072.283	0.607	351920.086	715938.08	3.42	352032.479	715919.235	0.85	351950.2	715970.833	1.324			
351897.029	716062.03	1.237	351923.343	715941.457	3.08	352037.415	715926.757	0.499	351931.317	715978.305	1.623			
351886.832	716054.689	1.767	351927.245	715945.122	2.832	352045.377	715934.611	0.276	351916.645	715980.679	1.863			
351878.091	716048.018	2.181	351930.829	715948.291	2.316	352051.202	715941.643	0.122	351906.764	715989.286	1.887			
351871.181	716042.793	2.709	351935.614	715951.984	1.86	352057.104	715949.874	-0.16	351898.66	715989.578	2.584			
351864.993	716037.706	3.133	351945.105	715959.604	1.635	352064.025	715922.393	0.424	351892.566	715991.177	2.958			
351862.457	716035.754	3.437	351954.583	715967.782	1.283	352059.062	715913.403	0.66	351887.303	715989.757	3.242			
351860.496	716035.001	3.807	351963.777	715975.49	0.905	352048.873	715901.219	0.989	351883.995	715987.382	3.708			
351876.982	716003.082	3.45	351972.818	715984.246	0.595	352043.773	715892.068	1.268	351888.035	716020.482	2.007			
351883.393	716007.859	2.937	351981.181	715991.268	0.314	352040.481	715886.356	1.319	351915.702	716049.739	0.84			
351889.554	716011.186	2.376	351988.407	715998.019	0.095	352037.541	715879.406	1.605	351897.373	716059.949	1.271			
351893.03	716013.496	1.925	351997.804	716004.677	-0.07	352034.399	715872.971	1.942	351879.111	716068.455	1.783			

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H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351767.664	716296.111	3.292	351684.09	716576.256	3.144	351722.984	716494.236	1.129	351751.832	716434.042	1.138	351780.065	716372.175	1.331
351758.512	716328.447	2.898	351688.62	716575.625	3.009	351718.987	716489.487	1.559	351747.43	716429.452	1.003	351774.67	716366.591	1.316
351749.767	716351.418	2.999	351693.297	716575.166	2.856	351714.399	716484.628	2.048	351743.474	716425.203	1.015	351772.011	716364.626	1.028
351739.61	716371.431	2.931	351697.781	716574.93	2.609	351710.418	716479.819	2.417	351738.95	716420.273	1.382	351768.172	716362.333	1.036
351733.33	716386.085	3.073	351701.619	716574.613	2.455	351706.47	716475.295	2.781	351734.281	716414.423	1.933	351763.504	716358.398	1.584
351725.165	716409.125	2.869	351705.726	716574.112	2.12	351701.143	716470.18	3.175	351729.346	716409.226	2.456	351757.784	716353.58	2.263
351719.182	716427.191	2.916	351710.255	716573.759	1.714	351698.862	716467.033	3.333	351726.3	716404.862	2.914	351753.454	716348.858	2.766
351714.204	716442.874	2.831	351714.787	716573.427	1.458	351702.933	716468.672	3.144	351723.405	716400.003	3.35	351748.009	716343.558	3.165
351720.75	716449.701	2.194	351720.374	716573.165	1.189	351707.771	716470.013	2.891	351720.396	716401.348	3.622	351744.133	716340.531	3.603
351725.576	716455.355	1.626	351726.048	716572.848	1.01	351711.294	716471.254	2.616	351723.407	716392.559	3.614	351753.823	716313.478	3.653
351726.915	716460.805	1.295	351731.816	716572.565	0.878	351716.824	716472.758	2.048	351727.363	716394.082	3.147	351758.672	716315.458	3.195
351723.75	716478.402	1.228	351738.187	716572.681	0.804	351721.945	716474.52	1.551	351731.928	716395.495	2.698	351763.379	716317.011	2.852
351721.039	716497.45	1.187	351745.431	716572.942	0.716	351725.378	716475.311	1.201	351738.225	716397.685	2.087	351768.892	716318.809	2.338
351713.038	716493.511	2.021	351750.217	716573.193	0.789	351731.719	716476.923	1.015	351744.086	716399.933	1.555	351774.719	716320.888	1.676
351706.102	716488.752	2.594	351756.382	716573.372	0.832	351737.628	716478.537	1.244	351750.025	716402.214	1.151	351779.059	716322.439	1.165
351698.472	716488.851	3.061	351762.689	716573.318	0.735	351745.178	716479.873	1.281	351758.688	716405.639	0.999	351784.155	716324.402	0.952
351692.113	716488.346	3.664	351768.397	716573.131	0.628	351753.381	716481.374	1.207	351765.289	716407.617	0.885	351789.648	716326.136	0.961
351690.65	716501.289	3.589	351775.648	716573.091	0.396	351761.028	716482.907	1.069	351772.173	716410.032	0.815	351798.114	716329.008	1.042
351696.057	716504.707	3.072	351783.892	716572.822	0.041	351768.258	716484.376	0.886	351778.393	716411.89	0.942	351806.494	716331.527	1.023
351699.783	716507.076	2.966	351792.013	716572.231	-0.36	351777.16	716486.052	0.572	351787.148	716414.792	0.877	351815.114	716334.723	0.983
351703.69	716508.841	2.632	351798.49	716571.663	-0.66	351784.796	716487.766	0.318	351796.16	716417.877	0.719	351823.706	716336.93	0.928
351708.96	716510.78	2.075	351805.108	716571.036	-0.9	351793.066	716489.615	0.01	351804.088	716420.636	0.541	351832.105	716340.713	0.764
351714.272	716513.305	1.689	351813.282	716570.789	-1.06	351800.036	716491.258	-0.27	351810.884	716422.47	0.3	351839.857	716344.356	0.552
351720.282	716516.637	1.162	351823.147	716570.864	-1.2	351807.811	716492.943	-0.69	351818.227	716424.649	-0.1	351847.399	716348.376	0.298
351721.294	716530.312	1.134	351804.125	716564.33	-0.92	351815.15	716494.613	-1.06	351826.531	716427.471	-0.57	351855.013	716352.424	0.006
351714.855	716532.853	1.576	351797.192	716559.871	-0.69	351822.3	716495.807	-1.32	351834.094	716430.324	-1.01	351861.474	716355.74	-0.3
351706.873	716535.112	2.194	351789.591	716554.902	-0.27	351830.681	716497.06	-1.54	351840.685	716432.658	-1.34	351868.701	716358.81	-0.6
351701.498	716536.352	2.644	351781.884	716548.93	0.187	351821.08	716485.468	-1.24	351849.229	716435.566	-1.6	351877.151	716362.232	-1.02
351694.962	716537.662	2.96	351773.255	716541.925	0.509	351810.006	716477.369	-0.58	351840.689	716425.388	-1.22	351885.798	716365.775	-1.26
351689.99	716537.473	3.193	351766.279	716535.369	0.728	351803.089	716472.046	-0.18	351832.579	716417.961	-0.7	351893.612	716368.213	-1.35
351684.686	716537.252	3.761	351756.992	716527.488	0.968	351791.884	716465.081	0.277	351825.613	716411.334	-0.16	351899.366	716370.348	-1.51
351683.543	716551.232	3.717	351748.887	716521.042	1.145	351782.528	716459.455	0.663	351818.28	716404.427	0.277	351897.246	716355.359	-1.2
351689.459	716555.721	3.077	351741.573	716514.321	1.17	351771.991	716452.222	1.01	351809.843	716397.733	0.634	351886.043	716347.3	-0.81
351688.881	716566.457	3.119	351736.482	716509.679	1.154	351764.63	716446.669	1.196	351800.553	716390.631	0.949	351876.856	716339.723	-0.36
351677.971	716578.866	3.837	351731.175	716503.551	1.095	351757.382	716439.863	1.262	351793.373	716384.495	1.117	351868.731	716332.959	0.029
351679.109	716577.547	3.268	351728.438	716499.899	1.014	351757.274	716439.787	1.241	351786.975	716378.569	1.221	351858.43	716325.287	0.408

H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351847.582	716317.422	0.639	351930.645	716263.375	-1.42	351896.865	716180.975	0.697	351878.173	716098.148	0.874	351855.992	716045.402	3.707
351837.17	716310.174	0.715	351922.359	716256.706	-1.16	351905.443	716184.32	0.439	351884.793	716100.973	0.664	351863.681	716037.6	3.178
351828.379	716303.205	0.8	351915.521	716252.419	-0.95	351912.854	716186.607	0.169	351894.028	716104.295	0.461	351864.855	716025.875	3.702
351820.239	716296.938	0.902	351907.603	716246.623	-0.49	351920.187	716189.131	-0.16	351898.866	716106.411	0.415	351873.392	716019.975	3.037
351812.462	716291.784	0.905	351899.143	716240.8	-0.03	351927.956	716192.3	-0.58	351904.56	716108.243	0.744	351877.086	716002.957	3.363
351806.299	716287.292	0.938	351889.695	716234.975	0.411	351934.668	716195.323	-0.89	351912.229	716111.027	0.78	351880.041	716004.431	3.121
351802.864	716284.227	0.855	351880.889	716229.666	0.77	351940.725	716197.657	-1.23	351920.149	716113.963	0.648	351885.784	716007.823	2.97
351797.592	716280.78	1.03	351871.749	716224.365	0.903	351947.35	716200.324	-1.41	351927.994	716116.575	0.435	351890.58	716010.418	2.524
351792.049	716277.684	1.705	351864.202	716219.043	1.031	351953.84	716202.368	-1.6	351935.485	716119.34	0.193	351894.988	716012.273	2.148
351786.905	716274.974	2.327	351857.601	716214.121	1.093	351951.315	716187.989	-1.44	351942.83	716121.957	-0.03	351901.676	716016.29	1.708
351782.191	716271.683	2.943	351853.679	716211.212	0.984	351942.289	716182.376	-0.96	351950.47	716124.492	-0.26	351908.549	716019.75	1.463
351776.695	716267.301	3.275	351850.919	716209.571	0.803	351931.972	716176.675	-0.45	351957.432	716126.542	-0.5	351917.238	716024.813	1.176
351773.041	716264.836	3.892	351842.157	716203.911	0.831	351923.158	716172.203	-0	351964.542	716128.669	-0.77	351925.261	716029.775	0.827
351777.313	716254.062	3.867	351834.514	716199.243	0.962	351915.179	716167.384	0.334	351970.248	716130.317	-1.07	351934.738	716034.905	0.595
351783.277	716237.904	3.937	351829.147	716195.178	1.71	351906.017	716161.464	0.638	351976.087	716131.325	-1.29	351943.778	716040.028	0.369
351786.175	716238.978	3.442	351821.78	716190.681	2.273	351897.695	716155.66	0.828	351980.159	716132.737	-1.31	351949.026	716043.022	0.409
351789.942	716240.586	3.078	351815.828	716188.17	2.787	351889.542	716150.157	0.934	351984.443	716133.888	-1.61	351960.41	716049.227	0.284
351794.277	716242.552	2.714	351811.539	716185.769	3.203	351882.574	716145.704	0.88	351984.731	716114.371	-1.23	351968.986	716053.971	0.08
351799.78	716244.792	2.212	351807.056	716182.89	3.375	351879.394	716144.172	0.598	351976.422	716109.848	-0.92	351978.312	716059.18	-0.18
351804.417	716246.837	1.776	351804.164	716181.261	3.939	351872.243	716140.835	0.395	351970.468	716106.266	-0.67	351986.796	716064.2	-0.49
351809.631	716248.817	1.328	351812.004	716173.512	3.243	351866.789	716138.32	0.423	351963.208	716102.941	-0.39	351993.405	716068.253	-0.75
351813.53	716250.198	1.035	351814.071	716153.731	3.728	351860.744	716134.576	0.781	351954.04	716098.062	-0.07	352001.701	716073.424	-1.09
351823.684	716254.295	0.858	351816.802	716154.74	3.287	351855.539	716131.579	1.29	351945.921	716094.528	0.159	352009.752	716078.208	-1.44
351833.099	716257.651	0.713	351823.268	716156.765	3.245	351847.067	716128.603	1.959	351937.672	716091.326	0.355	352018.181	716082.577	-1.75
351841.288	716260.43	0.487	351827.513	716158.22	2.813	351841.636	716125.821	2.402	351929.543	716087.611	0.514	352025.722	716069.161	-1.64
351850.949	716262.549	0.61	351831.45	716159.247	2.359	351837.423	716124.068	2.977	351921.58	716084.373	0.641	352014.184	716058.066	-1.08
351860.276	716264.913	0.727	351837.696	716160.825	1.848	351830.967	716121.071	3.158	351914.28	716080.205	0.339	352003.045	716048.968	-0.63
351868.256	716267.202	0.668	351844.255	716162.711	1.312	351826.57	716119.224	3.541	351907.028	716076.41	0.401	351992.483	716041.779	-0.28
351878.283	716270.454	0.44	351848.526	716163.729	0.864	351840.696	716101.164	3.152	351899.989	716072.245	0.55	351982.433	716034.068	-0
351887.456	716273.188	0.169	351856.005	716166.675	0.574	351839.35	716085.127	3.735	351894.433	716069.405	0.79	351972.828	716026.493	0.224
351897.63	716274.809	-0.3	351862.074	716169.13	0.761	351842.058	716085.978	3.279	351888.114	716065.159	1.315	351964.045	716018.768	0.32
351905.947	716276.707	-0.73	351865.931	716170.725	0.823	351847.941	716088.103	3.069	351882.141	716060.853	1.614	351955.987	716012.863	0.256
351914.223	716278.568	-1.09	351867.738	716171.407	1.105	351852.806	716089.826	2.686	351875.996	716056.435	1.983	351947.28	716004.737	0.593
351923.636	716281.06	-1.35	351875.086	716173.883	1.063	351859.279	716091.735	2.097	351871.14	716052.982	2.466	351938.375	715997.369	1.028
351932.182	716284.032	-1.54	351883.261	716176.229	0.91	351866.208	716093.859	1.718	351867.212	716050.612	2.929	351928.556	715988.561	1.385
351939.283	716272.296	-1.57	351890.863	716178.499	0.812	351872.694	716096.169	1.324	351861.387	716047.845	3.116	351919.168	715981.163	1.799

Beach Profile Data Collection
17th December 2001

H	D	V	H	D	V	H	D	V
351913.861	715976.223	2.24	351967.678	715892.677	3.044	352061.548	715882.722	1.126
351909.184	715970.996	2.736	351982.107	715889.514	2.721	352057.457	715874.06	1.422
351905.596	715966.52	3.102	351991.715	715879.364	2.89	352055.438	715867.761	1.582
351901.53	715961.489	3.551	352000.85	715874.123	3.022	352054.033	715861.054	2.105
351914.043	715953.534	3.103	352003.208	715877.579	2.63	352052.482	715855.615	2.681
351919.922	715938.239	3.355	352007.705	715882.629	2.191	352051.731	715852.699	3.002
351923.26	715940.951	3.055	352013.385	715889.169	1.647	352039.86	715863.08	2.509
351927.87	715944.063	2.88	352018.388	715893.602	1.601	352034.592	715870.225	2.06
351933.47	715948.238	2.3	352024.379	715900.387	1.375	352021.482	715873.398	2.242
351940.515	715953.942	1.784	352029.449	715908.097	1.071	352014.378	715867.565	2.885
351948.268	715960.394	1.463	352034.576	715915.109	0.753	351785.937	716282.427	2.052
351956.088	715966.925	1.163	352039.545	715921.633	0.54	351779.007	716283.549	2.671
351963.746	715973.379	0.861	352043.754	715925.638	0.456	351773.605	716281.401	3.238
351971.116	715979.567	0.51	352050.195	715932.175	0.176	351767.546	716277.248	3.473
351980.213	715986.2	0.249	352052.924	715935.474	0.063			
351990.659	715993.984	0.059	352057.081	715939.822	-0.02			
351999.41	716000.845	0.004	352063.604	715947.077	-0.05			
352010.613	716009.354	-0.18	352070.379	715955.973	-0.24			
352018.682	716015.786	-0.42	352075.863	715963.24	-0.43			
352028.634	716022.808	-0.76	352081.052	715969.853	-0.66			
352038.129	716029.53	-1.16	352086.359	715977.26	-0.97			
352046.245	716035.651	-1.47	352090.352	715982.892	-1.25			
352054.051	716041.147	-1.77	352094.106	715987.671	-1.46			
352048.869	716019.443	-1.26	352098.503	715993.477	-1.71			
352039.615	716005.061	-0.69	352112.965	715983.846	-1.65			
352032.028	715993.728	-0.27	352109.04	715971.847	-1.24			
352023.208	715978.949	-0.06	352104.46	715962.277	-0.81			
352014.094	715965.725	0.183	352100.138	715952.476	-0.49			
352007.689	715953.506	0.482	352096.387	715944.166	-0.26			
352001.464	715942.525	0.797	352093.236	715936.611	-0.04			
351993.609	715931.213	1.179	352088.956	715926.676	-0.01			
351986.506	715922.532	1.497	352084.738	715918.459	0.196			
351980.173	715914.262	1.754	352081.987	715913.145	0.375			
351975.455	715908.087	2.088	352072.831	715904.995	0.731			
351971.406	715902.416	2.527	352069.418	715897.623	0.935			
351969.141	715898.293	2.998	352067.495	715893.419	0.963			

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351679.86	716576.303	3.139	351739.064	716399.285	1.272	351856.185	716272.639	0.017	351940.702	716046.954	0.087	352052.264	715863.946	1.633
351677.929	716578.853	3.475	351754.211	716404.671	0.749	351884.432	716280.56	-0.37	351921.719	716033.457	0.562	352063.283	715880.145	0.892
351680.011	716576.686	2.996	351775.411	716411.999	0.226	351911.346	716286.893	-0.81	351901.157	716019.053	1.184	352069.767	715895.748	0.428
351689.188	716574.688	2.564	351790.634	716417.034	-0.14	351935.13	716293.49	-1.27	351893.806	716014.069	1.543	352085.462	715910.368	0.215
351699.815	716574.672	1.924	351798.078	716419.184	-0.19	351960.7	716299.018	-1.72	351886.192	716008.772	2.47	352100.587	715926.227	-0.38
351711.218	716574.799	1.403	351799.184	716419.325	-0.02	351976.365	716237.131	-1.66	351876.96	716003.026	3.404	352113.825	715942.333	-0.15
351724.699	716574.026	0.969	351812.738	716424.093	-0.24	351950.551	716222.986	-1.19	351882.741	715992.791	3.378	352124.706	715958.086	-1.27
351739.957	716573.158	0.514	351822.997	716427.814	-0.48	351927.239	716210.477	-0.77	351886.985	715982.171	3.518	352129.779	715964.189	-1.74
351756.424	716571.848	0.09	351833.754	716432.011	-1.08	351890.484	716190.619	-0.12	351892.139	715984.212	3.053	352054.828	715990.573	-0.85
351772.317	716570.943	0.002	351844.7	716436.211	-1.71	351856.925	716172.906	0.559	351897.296	715986.608	2.475	352021.424	716003.807	-0.6
351785.941	716571.12	-0.2	351846.388	716414.036	-0.99	351838.198	716164.574	1.097	351908.544	715991.859	1.457	351979.513	716022.406	-0.26
351801.45	716570.251	-0.68	351838.893	716402.134	-0.55	351828.922	716160.079	1.486	351920.936	715992.276	1.108	351927.557	716046.144	0.282
351816.768	716570.028	-1.31	351894.919	716400.885	-1.71	351823.027	716157.623	2.195	351918.426	715964.774	2.212	351898.042	716062.188	0.667
351835.658	716569.851	-1.37	351883.604	716392.807	-1.15	351815.753	716154.309	2.977	351920.141	715938.192	3.359	351871.815	716062.497	1.317
351850.867	716568.746	-0.79	351861.72	716379.795	-0.75	351814.049	716153.672	3.607	351924.626	715942.427	2.747	351863.464	716060.528	2.027
351806.455	716539.955	-0.82	351838.185	716364.979	-0.33	351821.903	716135.476	3.09	351931.039	715947.756	2.248	351855.255	716057.816	2.876
351792.33	716535.852	-0.21	351817.904	716351.427	0.061	351829.426	716135.679	2.308	351939.293	715954.155	1.412	351850.938	716056.476	3.513
351776.248	716531.057	0.192	351801.513	716338.816	0.471	351839.133	716136.478	1.37	351958.461	715970.589	0.763	351820.591	716196.878	1.316
351764.359	716526.874	0.129	351781.755	716327.855	1.007	351856.402	716135.034	0.899	351982.066	715990.895	0.145	351811.148	716196.843	2.045
351788.487	716519.186	-0.02	351769.082	716321.663	1.468	351849.212	716118.288	1.34	352000.785	716006.969	-0.33	351803.443	716195.124	2.801
351835.211	716501.53	-1.66	351758.918	716316.334	2.543	351843.601	716110.569	1.809	352019.778	716021.173	-0.79	351799.479	716193.993	3.541
351820.528	716496.309	-0.95	351754.27	716313.84	2.993	351835.519	716099.741	2.945	352035.573	716032.774	-1.22	351752.583	716313.295	4.039
351806.437	716492.601	-0.43	351753.864	716313.547	3.494	351834.449	716098.495	3.401	352050.184	716041.084	-1.65	351747.546	716331.656	2.775
351789.863	716488.419	-0.13	351764.173	716290.309	2.949	351839.325	716085.197	3.448	352078.085	716006.451	-1.61	351751.959	716334.077	2.442
351769.621	716483.434	0.039	351772.395	716292.683	2.406	351846.647	716087.449	2.483	352067.187	715986.84	-0.96	351760.107	716338.707	1.514
351752.864	716479.148	0.327	351781.292	716295.006	1.566	351856.387	716090.393	1.429	352054.399	715964.556	-0.45	351761.428	716393.339	0.679
351737.991	716475.87	0.693	351801.711	716295.354	0.916	351882.761	716098.341	0.65	352038.388	715937.125	0.065	351755.421	716426.549	0.523
351721.393	716471.932	1.226	351786.818	716272.165	1.823	351908.851	716107.723	0.052	352027.115	715919.637	0.509	351755.595	716491.658	0.284
351709.307	716469.374	1.998	351776.707	716264.364	2.842	351936.238	716117.637	-0.51	352017.526	715904.495	0.992	351735.291	716502.746	0.732
351698.866	716466.99	3.326	351773.666	716262.908	3.577	351962.12	716126.757	-1.13	352012.465	715894.579	0.923	351712.354	716509.187	1.509
351732.745	716447.288	0.967	351783.093	716237.848	3.576	351993.229	716136.896	-1.65	352004.965	715882.088	1.973	351704.471	716510.518	2.19
351718.798	716441.788	1.67	351785.261	716239.15	3.317	351981.917	716115.892	-0.67	352002.09	715876.628	2.392	351696.81	716511.729	2.726
351711.168	716438.461	2.543	351787.992	716240.329	2.719	351981.979	716116.327	-1.45	352000.601	715873.733	2.791	351694.491	716512.778	3.173
351707.122	716436.409	3.203	351793.311	716242.645	2.283	352008.007	716098.108	-1.66	352019.451	715868.395	2.231	351687.943	716512.974	3.603
351723.591	716392.624	2.625	351801.105	716245.936	1.39	351988.59	716084.321	-1.17	352024.078	715873.193	1.571	351627.446	716564.46	3.653
351729.478	716395.441	2.063	351823.448	716257.035	0.703	351967.63	716067.274	-0.59	352047.999	715855.417	2.439	351600.256	716564.955	3.752

Beach Profile Data Collection
30th January 2002

H	V	D
351598.621	716513.213	3.24
351597.677	716490.459	3.162
351602.055	716470.183	3.242

2nd February 2002

H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351752.474	716313.258	5.688	351689.504	716554.847	3.217	351729.04	716503.965	1.417	351718.198	716431.858	2.969	351749.161	716357.713	2.694
351766.486	716284.051	3.691	351684.472	716564.163	3.391	351723.84	716501.364	1.364	351713.738	716430.108	3.482	351744.451	716354.811	3.28
351761.466	716293.45	3.828	351677.922	716578.933	3.79	351717.968	716496.785	1.524	351710.107	716428.437	3.808	351739.516	716352.436	3.79
351757.398	716303.794	3.808	351678.928	716577.165	3.295	351713.783	716493.68	1.93	351720.126	716422.117	3.17	351765.9	716346.832	1.826
351749.334	716326.987	3.782	351683.594	716575.61	3.302	351707.908	716490.347	2.457	351729.782	716420.235	2.271	351761.343	716340.096	2.323
351743.588	716341.564	3.801	351688.425	716574.869	3.122	351702.261	716486.894	2.992	351734.082	716419.736	1.836	351755.83	716335.206	2.959
351737.576	716357.532	3.807	351693.581	716574.467	2.922	351697.823	716484.34	3.386	351723.407	716392.662	3.739	351751.35	716331.204	3.522
351731.058	716373.093	3.794	351697.295	716573.819	2.812	351699.117	716466.927	3.632	351727.743	716394.288	3.373	351753.831	716313.51	3.82
351725.769	716386.482	3.775	351702.913	716573.265	2.385	351702.419	716467.739	3.427	351733.668	716396.612	2.753	351757.779	716314.979	3.514
351719.155	716403.888	3.76	351709.612	716573.279	1.976	351707.822	716468.866	2.865	351738.403	716398.235	2.259	351762.495	716316.745	3.02
351714.414	716416.234	3.793	351717.144	716573.098	1.632	351713.513	716470.277	2.346	351742.264	716399.49	1.866	351768.276	716318.939	2.491
351710.126	716428.075	3.807	351725.33	716572.719	1.321	351718.653	716470.936	1.861	351747.523	716401.329	1.657	351773.787	716321.177	2.11
351705.479	716440.185	3.776	351733.004	716573.142	1.18	351724.082	716472.234	1.536	351752.07	716402.514	1.588	351779.394	716323.503	1.63
351700.731	716454.166	3.672	351739.122	716572.898	1.209	351727.889	716472.948	1.468	351754.326	716402.942	1.731	351784.968	716325.88	1.458
351696.132	716470.207	3.694	351746.731	716572.118	1.204	351733.324	716473.701	1.598	351761.972	716405.674	1.723	351792.769	716329.195	1.528
351693.421	716482.114	3.688	351753.077	716571.77	1.092	351740.882	716473.889	1.551	351769.99	716408.491	1.484	351799.505	716332.38	1.432
351691.755	716493.105	3.644	351760.218	716571.641	0.827	351747.811	716474.74	1.528	351777.688	716411.502	1.153	351807.948	716336.288	1.274
351690.641	716502.325	3.614	351766.527	716571.716	0.523	351754.745	716476.363	1.253	351786.835	716414.503	0.665	351814.724	716340.025	1.082
351695.21	716504.132	3.34	351774.095	716571.933	0.098	351763.305	716477.554	0.855	351794.667	716417.598	0.206	351823.857	716344.951	0.675
351700.543	716504.915	2.923	351781.866	716572.83	-0.25	351771.977	716479.468	0.364	351801.093	716420.188	-0.18	351831.138	716349.654	0.236
351705.875	716506.887	2.436	351790.206	716573.253	-0.58	351780.729	716481.152	-0.04	351808.392	716423.296	-0.61	351838.128	716353.69	-0.12
351710.638	716508.368	2.047	351797.213	716572.867	-0.76	351788.043	716482.931	-0.41	351813.707	716425.634	-0.88	351843.184	716357.175	-0.44
351715.976	716510.074	1.593	351803.894	716572.592	-0.91	351794.903	716484.137	-0.75	351820.189	716428.437	-1.26	351850.451	716361.421	-0.74
351722.171	716511.375	1.323	351811.683	716571.976	-1.05	351801.924	716485.753	-1.11	351823.237	716418.615	-1.17	351855.951	716364.6	-0.83
351724.203	716521.664	1.339	351807.923	716559.544	-1.07	351807.297	716466.226	-1.11	351830.321	716410.121	-1.27	351864.041	716369.975	-1.12
351726.938	716533.722	1.315	351799.116	716529.765	-0.9	351801.086	716462.11	-0.78	351824.968	716404.931	-0.89	351868.706	716359.628	-0.92
351719.441	716535.674	1.574	351790.297	716519.911	-0.63	351791.895	716458.992	-0.31	351815.889	716398.208	-0.37	351868.681	716352.375	-0.85
351712.734	716536.985	1.879	351781.02	716515.254	-0.18	351784.866	716456.209	0.043	351807.475	716392.753	0.093	351873.886	716343.221	-0.82
351707.573	716537.125	2.205	351772.676	716512.181	0.217	351775.351	716452.541	0.532	351797.393	716386.633	0.689	351867.462	716339.678	-0.69
351701.911	716537.691	2.604	351765.459	716509.481	0.575	351765.101	716448.727	1.115	351789.513	716382.353	1.124	351859.404	716334.203	-0.23
351696.8	716539.727	2.983	351758.207	716507.828	0.932	351755.846	716445.454	1.499	351781.205	716377.903	1.516	351850.28	716329.104	0.155
351691.961	716540.28	3.242	351750.204	716505.543	1.265	351747.372	716442.335	1.717	351773.453	716374.266	1.724	351841.87	716324.095	0.581
351687.309	716540.525	3.429	351741.758	716504.442	1.433	351738.87	716439.786	1.751	351766.865	716369.223	1.698	351832.684	716318.267	0.918
351681.744	716540.754	4.009	351741.186	716517.175	1.399	351731.662	716437.749	1.736	351763.381	716367.044	1.567	351822.857	716311.854	1.137
351680.18	716549.365	4.109	351732.104	716517.359	1.448	351727.782	716436.291	1.82	351758.33	716363.802	1.74	351813.115	716305.523	1.205
351683.813	716551.989	3.619	351734.66	716505.011	1.485	351722.61	716433.812	2.476	351753.895	716360.545	2.211	351802.715	716298.38	1.251

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H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351795.261	716292.295	1.425	351844.847	716222.002	0.894	351851.204	716130.042	1.796	351866.875	716050.886	2.929	351923.618	715983.041	1.387
351788.288	716286.299	2.033	351838.53	716219.048	1.084	351844.557	716126.386	2.238	351860.996	716047.325	3.407	351915.393	715975.96	2.166
351781.909	716280.757	2.691	351829.018	716213.383	1.26	351836.66	716123.331	3.029	351856.006	716044.97	3.717	351909.88	715971.276	2.838
351776.51	716276.286	3.211	351820.884	716209.105	1.805	351830.756	716120.77	3.608	351850.84	716056.773	3.768	351904.667	715967.512	3.422
351770.374	716272.1	3.685	351812.657	716205.493	2.387	351826.55	716119.197	3.744	351857.838	716059.226	3.448	351899.754	715963.828	3.584
351781.181	716268.696	3.221	351805.547	716202.038	3.21	351835.303	716113.567	3.508	351882.446	716047.38	1.789	351910.178	715961.176	3.45
351791.053	716266.506	2.338	351801.442	716199.52	3.678	351847.166	716106.717	2.602	351878.92	716035.631	2.453	351921.131	715959.668	2.596
351787.004	716252.803	3.2	351797.893	716198.369	4.006	351842.149	716095.692	3.632	351875.927	716024.776	3.065	351920.144	715938.393	3.508
351780.438	716245.215	3.888	351802.282	716186.489	3.949	351836.461	716092.768	3.713	351873.903	716017.81	3.544	351925.159	715942.335	3.227
351783.184	716237.881	3.927	351811.627	716187.162	3.122	351839.324	716085.081	3.743	351871.215	716013.126	3.565	351929.862	715946.025	2.764
351788.959	716240.333	3.493	351821.405	716187.6	2.222	351844.604	716087.339	3.395	351876.763	716003.255	3.627	351937.318	715951.779	1.953
351794.733	716242.535	2.765	351818.795	716172.605	2.955	351850.228	716089.418	2.936	351881.54	716006.089	3.292	351946.374	715959.166	1.399
351802.899	716245.892	2.09	351810.42	716164.265	3.729	351857.909	716092.276	2.188	351886.996	716009.375	2.786	351955.817	715966.485	1.001
351812.817	716249.991	1.587	351814.135	716153.611	3.795	351867.607	716095.79	1.571	351892.915	716012.524	2.189	351963.851	715972.774	0.818
351823.8	716254.586	1.194	351819.271	716155.634	3.473	351878.422	716100.428	1.018	351900.134	716016.817	1.545	351971.392	715979.687	0.592
351831.67	716257.682	1.048	351826.154	716158.089	2.828	351892.302	716106.099	0.867	351908.567	716022.406	0.818	351979.586	715987.379	0.427
351839.758	716260.866	1.009	351832.449	716160.585	2.195	351903.171	716111.131	0.72	351917.221	716026.977	0.692	351989.236	715996.138	0.242
351850.418	716264.331	0.944	351842.432	716165.307	1.576	351914.678	716115.761	0.545	351924.995	716031.285	0.755	351999.302	716004.135	0.085
351863.392	716269.179	0.513	351851.866	716170.044	1.104	351926.059	716120.808	0.284	351938.121	716039.37	0.588	352006.663	716009.337	-0.01
351873.816	716273.051	0.105	351861.871	716175.238	0.864	351938.12	716126.511	-0.04	351950.252	716046.234	0.355	352013.744	716014.464	-0.2
351883.253	716277.263	-0.24	351870.965	716179.22	0.951	351949.356	716132.279	-0.38	351961.462	716053.05	0.086	352018.953	716018.125	-0.43
351892.876	716281.541	-0.63	351882.416	716183.629	0.698	351961.741	716138.143	-0.7	351971.813	716058.971	-0.1	352027.812	716023.667	-0.85
351901.283	716284.765	-0.92	351895.275	716189.154	0.296	351972.302	716141.297	-1	351981.356	716064.611	-0.28	352035.682	716028.324	-1.17
351908.252	716287.502	-1.01	351905.568	716194.49	-0.04	351980.698	716144.846	-1.28	351990.282	716070.002	-0.6	352043.787	716032.254	-1.5
351920.046	716291.43	-1.18	351917.283	716200.724	-0.42	351988.308	716147.751	-1.46	352000.419	716075.078	-0.95	352052.746	716013.019	-1.53
351920.06	716291.455	-1.2	351925.695	716206.044	-0.67	352002.415	716119.825	-1.55	352008.041	716078.484	-1.19	352047.603	716003.799	-1.07
351930.407	716270.114	-1.27	351938.863	716213.653	-1.02	351994.349	716114.258	-1.31	352015.235	716081.123	-1.46	352040.459	715995.365	-0.63
351921.857	716263.452	-1.12	351950.663	716218.054	-1.33	351984.984	716109.417	-1.02	352023.127	716066.683	-1.43	352033.697	715987.468	-0.21
351914.568	716259.19	-1.01	351955.722	716198.26	-1.23	351969.384	716100.523	-0.5	352015.109	716058.799	-1.1	352025.023	715977.864	0.144
351908.146	716256.657	-0.99	351937.666	716182	-0.65	351954.339	716093.1	-0.13	352004.369	716048.024	-0.59	352017.396	715970.137	0.328
351903.315	716253.521	-0.7	351923.075	716172.883	-0.2	351937.846	716085.701	0.277	351991.371	716037.678	-0.18	352010.857	715961.783	0.443
351891.453	716246.625	-0.26	351913.255	716165.558	0.136	351923.037	716078.024	0.576	351979.038	716027.5	0.057	352006.32	715956.062	0.49
351879.192	716240.017	0.244	351901.265	716157.301	0.515	351909.627	716071.995	0.796	351967.569	716017.354	0.314	351999.764	715947.198	0.718
351866.503	716233.915	0.724	351888.38	716148.224	0.767	351896.116	716066.006	0.91	351955.962	716007.908	0.503	351990.797	715936.145	1.034
351857.99	716229.075	0.993	351873.733	716140.801	0.962	351883.972	716059.665	1.417	351942.728	715999.596	0.518	351982.657	715925.642	1.36
351849.086	716224.113	1.098	351859.656	716134.442	1.315	351873.727	716054.647	2.201	351932.111	715991.714	0.814	351975.036	715917.245	1.772

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H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351969.5	715911.076	2.113	352101.853	715925.509	0.064	351896.714	716362.046	-1.35	351877.638	716332.477	-0.84	351886.436	716339.513	-0.92
351965.625	715906.642	2.639	352090.097	715930.892	0.046	351886.062	716369.178	-1.32	351878.15	716333.065	-0.84	351886.66	716339.285	-0.99
351961.718	715902.582	3.147	352084.068	715920.978	0.202	351873.862	716376.719	-1.32	351878.517	716333.597	-0.81	351886.603	716339.367	-1
351958.562	715899.168	3.369	352078.851	715913.476	0.444	351865.531	716381.557	-1.37	351878.581	716334.311	-0.8	351887.302	716339.662	-0.96
351953.738	715910.279	3.277	352078.768	715913.43	0.438	351858.527	716388.014	-1.35	351879.095	716334.571	-0.82	351888.044	716340.172	-0.94
351947.015	715909.209	3.352	352072.068	715904.352	0.731	351846.679	716386.53	-1.11	351879.47	716334.936	-0.85	351888.925	716340.99	-0.97
351980.829	715904.914	1.892	352069.158	715896.85	0.877	351843.199	716378.26	-0.85	351879.891	716335.189	-0.85	351888.703	716341.244	-1
351984.897	715893.05	2.338	352065.706	715885.939	0.923	351842.484	716370.644	-0.68	351880	716335.646	-0.88	351888.807	716341.348	-1.06
351984.387	715883.668	2.891	352061.754	715878.741	1.224	351843.368	716359.274	-0.51	351880.553	716335.646	-0.87	351888.854	716341.304	-0.96
352000.691	715873.793	3.138	352057.025	715874.096	1.385	351849.646	716356.06	-0.55	351880.502	716336.095	-0.86	351889.317	716341.721	-0.99
352003.756	715877.573	2.628	352053.196	715863.059	1.978	351855.469	716352.056	-0.62	351880.356	716336.518	-0.78	351889.688	716341.962	-1.01
352009.751	715884.186	2.095	352051.97	715857.933	2.484	351859.988	716351.865	-0.65	351880.283	716336.659	-0.9	351889.995	716342.114	-1
352015.198	715889.612	1.5	352051.142	715853.249	2.936	351864.248	716347.921	-0.71	351880.6	716337.315	-0.91	351890.288	716342.294	-1.03
352018.219	715893.621	1.558	352038.263	715857.471	3.015	351868.832	716352.358	-0.86	351880.626	716337.281	-0.74	351890.807	716342.55	-1.01
352023.222	715902.51	1.205	352034.182	715866.936	2.219	351875.656	716357.915	-1.05	351881.119	716337.552	-0.9	351891.266	716342.574	-1.06
352029.937	715912.018	0.873	352019.321	715865.013	2.932	351880.107	716363.928	-1.19	351881.268	716337.367	-0.79	351891.51	716342.847	-1.03
352037.568	715921.593	0.653	352015.847	715875.29	2.236	351880.974	716352.429	-1	351881.706	716337.965	-0.92	351892.375	716342.883	-1.05
352043.078	715930.046	0.4	351996.447	715915.204	1.214	351874.253	716333.402	-0.79	351881.719	716337.706	-0.78	351892.522	716342.636	-1.05
352047.082	715936.02	0.309	351984.518	715945.735	0.944	351878.84	716325.162	-0.85	351882.675	716338.361	-0.91	351891.707	716342.46	-1.05
352052.855	715945.305	0.139	351965.13	715986.816	0.577	351884.515	716316.967	-0.84	351882.817	716338.219	-0.83	351891.024	716341.894	-1.05
352061.236	715955.709	-0.14	351956.282	716017.063	0.469	351888.799	716312.951	-0.9	351883.173	716338.605	-0.93	351889.836	716341.543	-1.03
352066.464	715964.271	-0.4	351942.101	716058.086	0.367	351894.156	716307.198	-0.97	351883.561	716338.662	-0.92	351889.568	716341.405	-0.99
352070.8	715973.234	-0.74	351931.356	716097.313	0.312	351899.035	716308.171	-1.06	351883.57	716338.563	-0.84	351889.2	716340.948	-0.99
352075.37	715981.588	-1.04	351919.867	716131.455	0.328	351895.582	716312.449	-0.97	351884.11	716338.957	-0.87	351886.648	716339.063	-0.99
352080.889	715990.772	-1.51	351908.422	716173.693	0.164	351897.656	716316.651	-1.08	351884.03	716339.065	-1.02	351886.203	716339.021	-0.95
352091.515	715983.807	-1.44	351914.138	716199.88	-0.34	351903.737	716321.235	-1.18	351884.405	716339.176	-0.84	351885.737	716338.891	-0.91
352111.088	715980.881	-1.53	351918.732	716219.173	-0.68	351907.745	716324.896	-1.27	351884.51	716339.399	-0.95	351885.558	716339.109	-0.91
352108.869	715973.944	-1.3	351923.344	716233.441	-0.93	351893.03	716326.499	-1.02	351884.736	716339.519	-0.97	351885.157	716338.971	-0.92
352106.31	715967.381	-1.07	351927.618	716245.189	-1.12	351889.696	716331.286	-1.01	351884.952	716339.688	-0.94	351884.54	716338.532	-0.92
352102.656	715958.132	-0.87	351928.933	716256.709	-1.21	351884.316	716331.332	-0.95	351884.968	716339.682	-0.9	351884.312	716338.817	-0.84
352098.888	715950.68	-0.64	351930.624	716272.93	-1.29	351878.967	716331.725	-0.87	351885.387	716339.887	-0.9	351883.937	716338.208	-0.89
352095.06	715942.989	-0.16	351921.609	716278.776	-1.19	351874.839	716330.235	-0.74	351885.678	716340.014	-0.96	351883.699	716338.276	-0.82
352091.028	715936.026	-0.05	351927.164	716297.674	-1.34	351875.703	716330.971	-0.76	351885.924	716339.825	-0.92	351883.606	716337.82	-0.87
352116.673	715941.08	-0.36	351922.387	716319.651	-1.39	351876.224	716331.234	-0.74	351885.579	716339.86	-0.9	351883.15	716337.452	-0.87
352118.075	715927.055	-0.12	351911.827	716334.718	-1.37	351876.688	716331.711	-0.75	351886.108	716339.649	-0.95	351883.06	716337.572	-0.81
352109.899	715918.726	0.156	351899.645	716350.118	-1.31	351877.232	716332.2	-0.78	351886.539	716339.639	-0.99	351882.92	716337.259	-0.87

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H	V	D
351882.509	716336.743	-0.89
351882.302	716336.908	-0.82
351882.097	716337.048	-0.78
351882.027	716337.236	-0.82
351881.847	716337.451	-0.74
351881.781	716337.684	-0.77
351881.752	716337.73	-0.94
351881.842	716336.703	-0.87
351881.551	716336.657	-0.84
351881.338	716336.824	-0.84
351881.137	716336.916	-0.76
351881.115	716337.007	-0.75
351880.997	716337.106	-0.81
351881.038	716337.198	-0.92
351881.135	716336.286	-0.9
351880.993	716336.237	-0.89
351880.85	716336.268	-0.9
351880.624	716336.159	-0.9
351880.766	716336.328	-0.78
351880.808	716336.511	-0.79
351880.645	716335.445	-0.9
351880.445	716335.141	-0.91
351880.038	716334.574	-0.91
351879.434	716334.179	-0.89
351879.415	716334.071	-0.88
351879.102	716333.507	-0.89
351878.792	716333.154	-0.87
351878.343	716332.594	-0.84
351878.137	716332.031	-0.87
351878.098	716331.687	-0.87
351877.895	716331.3	-0.88
351877.812	716331.019	-0.88
351877.625	716330.863	-0.88
351876.927	716330.589	-0.85
351876.257	716329.859	-0.88
351875.752	716329.5	-0.86

H	V	D
351875.236	716329.931	-0.76
351877.615	716332.6	-0.78
351877.756	716332.697	-0.79
351882.594	716337.968	-0.95
351864.964	716323.599	-0.25
351854.69	716316.903	0.235
351846.735	716310.76	0.628
351834.542	716302.782	0.937
351823.742	716297.407	1.059
351809.496	716289.475	1.21
351797.611	716281.528	1.601
351787.8	716277.405	2.295
351782.103	716289.712	2.289
351778.77	716287.96	2.748
351775.773	716286.283	3.046
351772.578	716284.245	3.327
351769.5	716282.506	3.488
351766.131	716280.543	3.611
351765.687	716281.569	3.804
351766.44	716279.293	3.816
351761.484	716277.893	3.846
351756.689	716275.199	4.095
351752.684	716272.934	4.437
351751.896	716274.068	4.447
351753.495	716271.566	4.441

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351752.547	716312.991	5.613	351677.926	716578.843	3.733	351715.775	716469.33	2.329	351783.395	716416.465	0.312	351803.246	716294.872	1.928
351765.09	716282.774	3.742	351679.698	716576.03	3.263	351720.451	716470.178	2.111	351789.5	716419.574	-0.03	351796.913	716289.721	1.937
351761.548	716292.525	3.848	351684.761	716575.07	3.211	351725.731	716471.23	2.036	351794.006	716421.338	-0.33	351789.805	716284.581	2.071
351756.969	716305.095	3.838	351691.068	716574.32	3.006	351730.858	716472.438	2.022	351801.403	716405.086	-0.36	351784.685	716281.018	2.397
351750.631	716322.667	3.848	351696.353	716573.781	2.765	351738.125	716473.66	1.598	351809.673	716391.136	-0.32	351779.463	716277.206	2.752
351746.491	716334.503	3.857	351705.163	716573.025	2.388	351746.593	716475.316	1.151	351801.885	716385.095	0.185	351775.337	716274.222	3.107
351739.293	716352.685	3.874	351713.653	716572.624	2.205	351753.693	716476.786	0.851	351793.468	716379.437	0.661	351771.998	716272.329	3.437
351733.848	716366.454	3.866	351720.453	716571.955	2.049	351759.214	716477.474	0.66	351784.309	716372.712	1.124	351770.597	716271.316	3.747
351720.023	716401.491	3.899	351731.021	716572.425	1.776	351766.715	716478.991	0.264	351777.085	716365.984	1.617	351778.544	716266.846	3.077
351714.267	716416.732	3.947	351739.469	716572.117	1.322	351771.39	716479.806	0.008	351770.558	716362.622	2.111	351788.252	716262.87	2.468
351705.894	716439.21	3.856	351748.702	716572.113	0.836	351774.817	716480.647	-0.2	351763.288	716357.779	2.109	351785.855	716249.598	2.923
351695.013	716475.299	3.75	351756.982	716572.41	0.521	351776.755	716480.917	-0.31	351757.196	716354.86	2.405	351780.82	716244.503	3.857
351693.054	716484.054	3.714	351764.298	716572.653	0.233	351783.049	716453.441	-0.29	351750.534	716350.579	2.931	351783.233	716237.86	3.879
351699.326	716485.745	3.172	351772.519	716573.384	-0.12	351771.409	716448.8	0.447	351745.107	716348.209	3.43	351785.754	716238.709	3.387
351703.443	716486.309	2.898	351779.129	716573.216	-0.32	351761.858	716444.941	0.861	351741.338	716346.825	3.86	351793.221	716241.958	2.587
351707.49	716486.968	2.646	351778.456	716562.053	-0.28	351753.54	716441.847	1.213	351752.391	716335.196	3.259	351800.948	716246.194	2.042
351711.227	716487.354	2.439	351772.422	716551.884	-0.14	351747.181	716438.965	1.61	351753.938	716313.319	3.871	351810.009	716250.891	1.911
351715.62	716488.291	2.155	351767.075	716545.437	-0.04	351741.263	716435.856	2.04	351757.984	716315.051	3.391	351819.011	716254.933	1.8
351721.487	716489.813	2.052	351758.085	716537.775	0.323	351735.236	716434.439	1.978	351764.674	716318.152	2.807	351831.345	716261.571	1.345
351727.544	716491.35	2.071	351750.316	716531.856	0.721	351729.628	716432.241	2.072	351769.664	716320.49	2.474	351842.732	716266.566	0.932
351731.813	716492.356	1.734	351744.076	716525.609	1.039	351724.928	716430.43	2.338	351774.745	716323.06	2.113	351853.561	716272.317	0.523
351739.038	716529.167	1.256	351738.289	716520.252	1.309	351719.964	716428.549	2.857	351780.473	716326.063	2.069	351864.332	716276.744	0.191
351733.032	716535.93	1.602	351728.999	716517.245	1.79	351715.666	716426.879	3.338	351786.561	716330.135	2.085	351873.495	716280.974	-0.12
351726.847	716537.772	1.846	351724.049	716516.191	2.026	351711.363	716425.108	3.914	351791.886	716332.588	1.692	351880.789	716284.823	-0.29
351720.292	716539.116	1.978	351715.877	716513.93	2.126	351721.736	716420.101	2.953	351799.069	716337.123	1.231	351887.403	716286.997	-0.44
351714.094	716540.07	2.139	351709.914	716512.416	2.325	351731.471	716414.426	2.284	351807.007	716341.599	0.879	351894.521	716264.136	-0.43
351707.667	716540.789	2.331	351703.38	716511.146	2.654	351723.375	716392.719	3.904	351813.428	716345.602	0.609	351900.777	716248.965	-0.46
351702.874	716540.51	2.578	351697.293	716509.748	3.003	351726.919	716393.991	3.446	351818.04	716348.469	0.374	351891.869	716241.463	-0.21
351697.872	716540.434	2.797	351693.748	716508.72	3.298	351730.932	716395.97	2.967	351823.407	716352.347	0.037	351880.692	716233.819	0.06
351693.921	716540.242	3.024	351689.473	716507.369	3.688	351735.97	716398.177	2.482	351829.509	716355.14	-0.18	351871.841	716228.784	0.398
351689.823	716539.771	3.294	351690.878	716498.347	3.647	351740.521	716400.012	2.106	351852.018	716338.835	-0.45	351858.83	716223.167	0.831
351685.928	716539.636	3.506	351692.904	716489.589	3.636	351746.305	716402.487	2.049	351846	716332.367	-0.1	351845.626	716218.547	1.258
351681.901	716539.8	4.077	351698.904	716467.02	3.711	351752.904	716405.033	2	351835.105	716322.551	0.371	351834.971	716214.198	1.615
351683.874	716549.502	3.521	351702.239	716467.622	3.387	351759.303	716407.411	1.61	351824.753	716313.599	0.851	351824.491	716210.095	1.843
351684.006	716558.907	3.429	351706.867	716468.186	2.985	351767.291	716410.275	1.133	351817.345	716306.397	1.225	351815.602	716205.826	1.97
351684.105	716566.527	3.388	351711.514	716468.645	2.661	351773.802	716412.39	0.853	351808.975	716299.14	1.681	351810.791	716203.724	2.255

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351805.778	716201.113	2.843	351855.719	716117.297	2.166	351869.031	716031.188	3.034	351895.555	715970.453	3.661	352000.751	715873.819	2.919
351800.659	716198.435	3.433	351859.775	716118.245	1.714	351863.237	716028.991	3.716	351905.526	715968.489	2.988	352003.39	715877.228	2.482
351798.396	716197.531	3.911	351850.32	716103.813	2.069	351875.248	716022.805	2.858	351915.46	715969.344	2.563	352009.789	715884.519	1.867
351806.752	716190.707	3.064	351842.452	716098.414	2.933	351870.842	716013.683	3.514	351922.909	715972.976	2.196	352015.454	715889.739	1.429
351813.954	716188.145	2.522	351835.836	716094.418	3.819	351876.936	716003.07	3.62	351913.268	715946.369	3.712	352019.187	715893.678	1.398
351823.626	716182.735	1.935	351839.398	716085.186	3.762	351881.806	716006.143	3.041	351920.171	715938.306	3.64	352028.81	715903.258	1.002
351814.784	716170.11	2.964	351844.931	716086.511	3.097	351888.448	716009.77	2.586	351924.03	715941.327	3.145	352033.454	715910.301	0.857
351809.853	716165.997	3.685	351850.798	716088.397	2.598	351894.141	716013.538	2.294	351929.221	715944.941	2.64	352039.715	715918.005	0.624
351814.075	716153.712	3.747	351856.183	716090.084	2.06	351900.189	716017.533	2.189	351934.172	715949.094	2.387	352045.773	715925.638	0.324
351819.193	716156.143	3.055	351862.135	716092.164	2.104	351906.796	716021.663	1.496	351939.386	715953.342	2.153	352050.82	715933.049	0.333
351824.129	716158.591	2.523	351866.314	716093.735	2.182	351912.308	716024.806	0.914	351944.733	715957.756	2.101	352059.886	715941.851	0.138
351828.779	716160.912	1.978	351872.975	716095.814	1.534	351918.458	716028.821	0.845	351949.791	715961.588	1.557	352064.836	715948.142	-0.06
351838.25	716165.637	1.835	351880.917	716098.601	1.079	351927.467	716034.425	0.749	351957.315	715966.984	0.884	352069.363	715953.62	-0.21
351848.524	716169.09	1.511	351893.785	716103.907	0.888	351935.645	716039.39	0.585	351967.058	715975.451	0.693	352076.7	715962.785	-0.65
351861.003	716173.798	1.114	351908.597	716109.3	0.603	351946.503	716045.432	0.329	351976.391	715982.355	0.531	352105.208	715948.645	-0.68
351876.096	716180.329	0.745	351921.643	716114.424	0.297	351955.378	716050.316	0.137	351988.268	715990.203	0.45	352102.878	715939.857	-0.23
351876.066	716180.442	0.728	351932.12	716118.348	0.052	351959.509	716053.316	0.157	351998.887	715997.464	0.221	352098.502	715932.948	-0.07
351889.546	716186.893	0.304	351938.331	716120.129	-0.1	351965.579	716056.52	0.169	352009.033	716003.733	0.024	352094.024	715926.096	0.111
351902.92	716192.988	-0.06	351941.745	716121.209	-0.03	351974.045	716061.71	-0.15	352016.939	716008.164	-0.35	352089.455	715917.47	0.251
351912.32	716197.722	-0.28	351950.69	716125.409	-0.28	351983.715	716066.865	-0.61	352024.702	716011.647	-0.65	352100.061	715910.828	0.224
351921.188	716202.271	-0.51	351958.879	716127.583	-0.58	351983.833	716066.886	-0.62	352037.912	715991.062	-0.62	352114.84	715900.63	0.41
351932.882	716180.311	-0.49	351965.641	716107.393	-0.59	351994.679	716048.122	-0.56	352031.229	715975.65	0.07	352083.887	715909.324	0.436
351918.642	716170.556	-0.15	351970.074	716090.359	-0.52	351988.58	716042.303	-0.27	352021.919	715966.351	0.273	352072.098	715899.257	0.76
351904.642	716163.999	0.208	351961.454	716083.061	-0.07	351979.027	716034.597	0.135	352021.941	715966.241	0.231	352067.746	715890.312	1.01
351890.729	716157.483	0.574	351953.791	716078.904	0.226	351970.22	716028.842	0.263	352010.079	715951.096	0.565	352058.274	715878.017	1.231
351875.673	716151.238	0.961	351951.054	716077.24	0.155	351960.299	716022.81	0.379	351998.749	715940.97	0.775	352055.41	715870.364	1.454
351864.346	716145.411	1.199	351947.991	716075.477	0.029	351954.636	716019.96	0.425	351990.008	715933.331	1.043	352054.018	715864.348	1.83
351852.584	716139.596	1.664	351935.239	716067.955	0.346	351942.116	716009.629	0.7	351985.254	715927.069	1.616	352052.505	715859.421	2.281
351846.707	716136.35	2.042	351923.404	716060.862	0.665	351934.288	716004.145	0.805	351981.629	715922.318	2.012	352050.819	715856.074	2.679
351842.076	716133.003	1.959	351912.541	716055.161	0.819	351927.377	716000.084	0.756	351973.822	715915.642	2.166	352050.232	715853.213	2.966
351838.582	716130.894	2.144	351904.869	716050.959	0.849	351921.577	715996.012	1.446	351969.228	715909.981	2.267	352039.281	715857.529	2.859
351833.326	716128.187	2.757	351900.433	716048.451	0.929	351916.996	715991.494	2.074	351965.169	715905.346	2.702	352038.984	715865.966	2.194
351829.419	716126.013	3.156	351893.905	716044.514	1.638	351911.548	715985.399	2.272	351960.864	715900.547	3.104	352036.866	715881.887	1.445
351825.026	716123.901	3.73	351888.256	716042.172	2.136	351906.281	715980.032	2.613	351959.518	715898.532	3.397	352008.393	715916.893	1.234
351836.802	716119.734	2.73	351881.886	716038.664	2.272	351902.437	715975.844	2.888	351970.18	715891.71	3.205	351997.852	715920.123	1.337
351845.399	716117.342	2.046	351875.31	716034.932	2.546	351898.442	715972.459	3.308	351979.788	715892.873	2.498	351987.179	715916.624	1.926

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H	V	D
351963.147	715940.198	2.065
351967.921	715953.333	1.031
351941.695	715980.737	0.905
351929.021	715977.865	1.919
351908.218	716030.306	1.036
351895.188	716028.664	2.186
351883.823	716051.249	2.241
351870.658	716083.196	2.256
351871.131	716110.62	1.341
351825.544	716204.022	1.856
351801.415	716252.739	2.05
351790.567	716262.362	2.298
351767.006	716277.079	3.607

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351752.674	716313.522	5.567	351743.315	716348.948	3.609	351839.061	716466.474	-1.83	351887.325	716508.076	-1.83	351745.669	716573.368	1.16
351754.077	716313.914	3.902	351741.034	716348.253	4.092	351826.309	716465.655	-1.6	351879.004	716515.917	-1.68	351755.893	716573.195	0.894
351757.612	716314.791	3.48	351737.682	716357.822	4.003	351817.018	716463.765	-1.35	351863.698	716519.446	-1.58	351766.943	716573.87	0.43
351761.139	716316.075	3.301	351734.217	716366.376	3.927	351804.291	716462.203	-0.7	351861.636	716533.28	-1.51	351777.153	716573.541	-0.07
351766.484	716318.7	2.75	351730.576	716374.889	3.961	351791.228	716460.867	-0.07	351857.26	716543.852	-1.46	351786.756	716573.098	-0.5
351773.055	716321.216	1.9	351726.858	716384.277	4.063	351777.098	716459.842	0.32	351843.73	716543.062	-1.27	351794.4	716573.141	-0.84
351781.471	716324.26	1.405	351723.827	716392.481	3.931	351763.573	716457.021	0.729	351832.1	716541.85	-1.1	351802.83	716573.633	-1.08
351790.199	716327.968	0.998	351729.451	716394.218	3.238	351752.381	716453.852	1.008	351822.183	716541.283	-0.94	351809.554	716572.776	-1.05
351803.44	716333.205	0.584	351735.914	716396.117	2.824	351743.152	716450.731	1.07	351806.363	716539.695	-0.9	351820.854	716572.601	-0.96
351814.439	716336.969	0.516	351742.787	716398.698	2.063	351735.764	716447.64	1.263	351797.484	716539.569	-0.64	351837.623	716572.333	-1.27
351824.672	716340.468	0.333	351750.323	716401.244	1.353	351729.536	716444.973	1.846	351789.015	716537.753	-0.43	351851.611	716571.282	-1.44
351836.635	716344.603	0.131	351758.462	716403.833	0.946	351723.282	716440.539	2.618	351776.94	716536.012	0.035	351864.034	716571.156	-1.59
351849.135	716349.374	-0.16	351767.403	716406.761	0.809	351716.471	716437.858	3.163	351763.699	716533.342	0.529	351880.298	716569.444	-1.75
351861.466	716354.108	-0.52	351776.212	716409.786	0.893	351711.284	716435.321	3.505	351747.104	716531.231	0.874	351903.394	716566.45	-1.9
351871.386	716358	-0.8	351787.179	716413.081	0.584	351708.072	716434.161	3.955	351735.305	716529.941	1.142	351881.266	716555.66	-1.73
351885.358	716363.741	-1.15	351797.168	716416.304	0.212	351705.258	716442.993	3.905	351725.427	716529.081	1.5	351837.908	716555.164	-1.28
351897.07	716367.938	-1.25	351809.873	716419.664	-0.24	351701.707	716452.25	3.785	351715.706	716528.193	1.883	351823.228	716555.521	-1.03
351909.596	716372.666	-1.45	351820.855	716423.349	-0.76	351700.962	716457.607	3.76	351710.049	716527.724	2.244	351811.181	716556.497	-0.99
351928.35	716375.656	-1.65	351830.797	716426.84	-1.29	351699.165	716466.959	3.547	351704.012	716527.315	2.717	351778.692	716555.171	-0.12
351951.784	716379.217	-1.88	351839.524	716429.91	-1.56	351704.969	716468.334	3.258	351696.553	716526.748	3.064	351763.508	716554.513	0.553
351950.137	716399.488	-1.87	351850.513	716433.316	-1.84	351712.477	716469.804	2.775	351689.21	716526.094	3.435	351744.361	716554.469	1.154
351933.985	716399.95	-1.72	351856.818	716432.563	-1.95	351719.974	716471.36	1.983	351685.722	716525.774	3.885	351728.254	716549.214	1.514
351914.28	716396.698	-1.57	351864.237	716432.64	-2.09	351729.11	716472.879	1.392	351685.472	716534.582	3.695	351715.355	716549.22	1.966
351892.967	716392.549	-1.36	351869.581	716434.81	-1.99	351740.009	716475.319	1.13	351683.395	716545.808	3.688	351707.823	716548.892	2.411
351872.428	716389.711	-1.28	351875.149	716435.404	-1.87	351749.17	716477.4	0.957	351684.2	716555.077	3.473	351701.046	716548.405	2.805
351856.604	716387.37	-0.93	351886.717	716438.344	-1.64	351760.605	716479.622	0.633	351683.443	716564.485	3.424	351687.461	716522.932	3.712
351839.529	716384.582	-0.52	351900.497	716440.566	-1.67	351771.017	716481.781	0.268	351680.58	716571.336	3.479	351693.968	716516.43	3.159
351821.671	716381.174	-0.03	351917.076	716444.951	-1.85	351783.177	716484.529	-0.12	351678.135	716578.738	3.719	351702.346	716508.631	2.983
351804.381	716375.479	0.481	351932.456	716448.825	-1.97	351791.77	716486.073	-0.35	351682.945	716575.024	3.278	351705.531	716492.767	2.93
351792.085	716370.438	0.764	351923.137	716469.787	-2	351802.745	716488.457	-0.86	351688.486	716574.962	3.063	351698.417	716488.881	3.242
351781.669	716366.092	0.853	351904.529	716465.643	-1.97	351811.631	716490.342	-1.27	351695.658	716574.596	2.931	351693.049	716487.197	3.745
351774.454	716362.777	0.941	351887.645	716465.315	-1.91	351824.651	716492.819	-1.48	351701.953	716574.501	2.649	351695.507	716475.384	3.768
351765.073	716358.767	1.546	351874.102	716465.163	-1.88	351838.259	716495.396	-1.62	351705.66	716574.321	2.572	351709.595	716457.812	3.18
351757.748	716355.489	2.205	351860.015	716465.551	-1.88	351848.504	716498.148	-1.63	351714.167	716573.654	2.023	351715.209	716444.257	3.067
351753.191	716353.511	2.752	351851.974	716465.452	-2.01	351861.357	716501.519	-1.63	351724.134	716573.62	1.692	351729.061	716426.064	2.504
351747.519	716350.883	3.219	351845.541	716465.869	-1.94	351874.937	716505.119	-1.71	351734.879	716573.589	1.408	351738.611	716413.031	2.007

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351729.077	716406.785	2.94	351919.094	716282.07	-1.02	351821.678	716156.376	3.151	351811.695	716192.041	3.007	351941.612	716161.13	-0.57
351723.498	716403.118	3.455	351932.613	716286.372	-1.36	351828.632	716158.92	2.59	351816.379	716178.356	3.019	351925.072	716154.875	-0.16
351719.549	716404.364	3.922	351946.464	716290.654	-1.72	351835.009	716161.349	1.846	351820.215	716164.745	3.091	351904.801	716146.978	0.26
351730.985	716396.901	3.076	351957.834	716294.378	-1.87	351843.711	716164.679	1.371	351822.902	716152.999	3.193	351891.797	716142.373	0.483
351740.451	716381.816	2.869	351973.401	716297.944	-2.03	351856.404	716169.572	0.903	351819.628	716146.935	3.434	351879.786	716137.081	0.771
351749.602	716367.172	2.639	351983.372	716301.098	-2.17	351872.115	716175.361	0.606	351817.18	716145.656	3.734	351868.899	716131.303	0.956
351747.114	716352.285	3.21	351984.829	716331.855	-2.2	351887.645	716181.369	0.341	351821.851	716133.357	3.75	351858.657	716126.527	1.377
351744.588	716345.421	3.642	351965.471	716330.387	-2	351901.99	716187.145	0.011	351825.418	716123.821	3.686	351849.202	716124.07	1.857
351742.667	716344.361	4.034	351943.823	716326.322	-1.74	351915.778	716193.164	-0.31	351828.064	716115.921	3.68	351843.671	716122.303	2.324
351748.986	716336.517	3.526	351927.46	716323.269	-1.47	351928.429	716198.709	-0.64	351830.814	716108.438	3.683	351840.018	716120.925	2.841
351747.51	716331.955	3.984	351908.831	716318.412	-1.09	351940.434	716203.205	-1	351834.316	716099.111	3.758	351834.473	716117.856	3.256
351750.421	716323.641	3.979	351890.027	716312.732	-0.66	351953.071	716207.963	-1.38	351837.981	716089.764	3.678	351829.814	716115.637	3.499
351754.767	716324.831	3.439	351873.189	716308	-0.25	351962.661	716212.157	-1.73	351839.742	716085.237	3.682	351838.593	716109.693	3.154
351755.126	716310.757	3.887	351858.139	716303.031	0.103	351973.812	716216.868	-1.92	351844.95	716086.938	3.222	351845.595	716100.742	2.923
351758.527	716301.225	3.898	351844.957	716298.318	0.369	351986.55	716221.871	-2.11	351850.323	716088.844	2.931	351852.019	716084.339	3.026
351761.415	716293.265	3.844	351833.674	716294.446	0.478	351999.268	716227.266	-2.21	351856.478	716090.805	2.268	351843.092	716076.684	3.747
351764.513	716285.141	3.74	351820.029	716289.556	0.65	351992.385	716241.662	-2.26	351864.899	716094.042	1.699	351847.36	716066.217	3.714
351769.315	716288.675	3.361	351809.279	716285.32	1.09	351988.815	716261.321	-2.22	351873.147	716096.906	1.225	351852.527	716054.033	3.666
351775.438	716289.872	3.13	351800.938	716282.188	1.42	351979.445	716261.417	-2.15	351887.927	716103.012	0.898	351857.602	716042.474	3.646
351770.404	716272.639	3.395	351793.71	716279.179	1.658	351973.417	716259.381	-1.94	351898.862	716106.984	0.65	351863.423	716029.699	3.642
351772.845	716266.232	3.803	351788.612	716277.381	2.298	351964.95	716256.686	-1.84	351912.588	716111.805	0.325	351867.832	716019.673	3.438
351776.111	716258.171	3.78	351783.695	716275.27	2.947	351956.688	716254.442	-1.81	351929.353	716117.733	0.034	351872.052	716013.64	3.384
351778.839	716250.65	3.751	351776.907	716272.424	3.226	351946.804	716252.471	-1.66	351944.572	716123.718	-0.34	351875.406	716006.177	3.616
351782.255	716241.829	3.743	351786.573	716264.491	3.149	351933.121	716246.317	-1.09	351957.859	716128.566	-0.7	351877.511	716003.22	3.562
351783.403	716237.81	3.866	351791.503	716253.065	3.121	351916.518	716240.405	-0.67	351969.756	716132.248	-1.01	351882.75	716005.991	3.186
351787.338	716239.244	3.312	351792.109	716235.917	3.178	351896.67	716233.123	-0.21	351981.673	716136.794	-1.43	351887.593	716008.412	2.975
351792.592	716241.433	3.134	351785.92	716231.502	3.808	351880.85	716227.051	0.165	351991.044	716139.991	-1.69	351891.991	716010.724	2.431
351797.958	716243.13	2.79	351789.65	716222.159	3.862	351867.364	716222.129	0.414	352002.907	716143.796	-1.92	351897.032	716013.677	1.811
351803.567	716244.88	2.01	351792.876	716213.417	3.87	351852.113	716216.631	0.68	352012.741	716147.115	-2.06	351909.767	716020.13	1.222
351813.751	716247.958	1.436	351796.222	716204.473	3.841	351841.064	716212.225	0.932	352024.191	716150.471	-2.24	351925.152	716028.395	0.84
351828.317	716252.493	0.828	351799.44	716195.118	3.873	351831.475	716208.819	1.263	352012.522	716183.354	-2.2	351939.403	716035.777	0.521
351843.383	716257.213	0.467	351803.326	716184.679	3.765	351823.185	716205.312	1.652	352004.385	716180.906	-2.07	351954.629	716043.948	0.241
351858.089	716262.191	0.317	351807.118	716173.993	3.682	351816.275	716202.71	2.294	351994.178	716177.711	-1.94	351968.731	716051.61	-0.12
351870.22	716265.874	0.11	351810.322	716165.439	3.659	351811.799	716200.91	2.867	351982.85	716173.702	-1.79	351984.394	716058.904	-0.59
351883.808	716270.541	-0.18	351813.134	716157.622	3.668	351806.553	716198.652	3.269	351971.6	716170.45	-1.58	351996.568	716065.081	-0.99
351900.53	716275.972	-0.56	351814.627	716153.837	3.696	351801.812	716196.957	3.407	351957.007	716165.451	-1.04	352009.027	716071.489	-1.37

Beacl Pr lil Data Colle ti i
25th May 2002

H	V	D	H	V	D	H	V	D	H	V	D
352020.161	716077.717	-1.94	351935.525	715948.573	2.374	351931.402	715937.063	3.069	352057.244	715867.254	1.483
352028.41	716081.829	-2.02	351939.657	715951.215	1.78	351927.746	715930.052	3.601	352055.011	715860.415	2.127
352039.547	716086.683	-2.13	351950.507	715959.279	1.338	351934.499	715923.816	3.368	352052.268	715853.532	2.797
352051.329	716090.636	-2.24	351960.009	715966.434	1.019	351940.365	715917.553	3.443	352042.337	715856.635	2.918
352030.911	716118.982	-2.2	351972.255	715975.106	0.754	351948.409	715908.233	3.524	352042.086	715866.859	1.915
352015.8	716112.913	-2.01	351982.865	715982.795	0.675	351957.845	715900.723	3.447	352031.269	715871.77	1.795
352002.541	716106.522	-1.72	351991.698	715989.818	0.392	351965.624	715894.894	3.333	352024.838	715863.92	2.646
351990.829	716101.238	-1.32	352002.305	715997.433	0.022	351973.936	715889.461	3.152	352015.341	715867.314	2.809
351973.59	716092.987	-0.77	352012.388	716004.639	-0.39	351982.83	715884.436	3.007	352017.129	715874.734	2.042
351960.073	716086.005	-0.34	352023.173	716012.757	-0.8	351993.796	715877.951	2.857	351969.823	715894.363	3.079
351942.091	716077.163	0.153	352033.386	716020.361	-1.2	352000.86	715874.013	3.002	351971.32	715900.662	2.78
351926.034	716069.688	0.447	352042.398	716026.72	-1.63	352003.964	715878.805	2.372	351974.943	715906.736	2.208
351908.156	716061.229	0.866	352049.357	716031.386	-1.72	352009.852	715884.832	1.982	351983.112	715915.564	1.586
351895.914	716055.224	1.146	352060.33	716037.779	-1.9	352019.229	715893.488	1.394	351990.415	715923.817	1.315
351887.465	716051.23	1.474	352070.634	716044.026	-2.11	352027.243	715899.766	1.048	351999.615	715933.574	0.902
351882.471	716049.255	1.727	352070.638	716044.129	-2.11	352031.739	715904.706	0.791	352006.7	715941.681	0.808
351877.336	716047.096	2.021	352063.394	716064.766	-2.15	352035.986	715909.383	0.726	351961.761	715926.024	1.825
351873.057	716045.065	2.644	352049.34	716061.691	-1.99	352044.66	715920.095	0.399	351950.641	715937.355	1.88
351868.165	716042.838	3.097	352038.149	716054.371	-1.74	352051.068	715927.945	0.501	351931.276	715961.862	1.78
351862.777	716040.432	3.307	352027.334	716046.714	-1.48	352058.695	715937.15	0.223	351916.9	715981.096	1.801
351873.804	716034.73	2.982	352015.911	716038.186	-1.02	352067.339	715948.814	-0.25	351905.203	715998.547	1.842
351880.012	716024.765	2.91	352004.014	716028.45	-0.61	352075.152	715959.011	-0.71	351894.363	716017.679	1.836
351884.878	716016.434	2.92	351992.246	716020.515	-0.19	352082.936	715968.825	-1.17	351885.571	716032.82	1.9
351891.304	716003.876	2.88	351981.783	716013.098	0.182	352090.297	715977.352	-1.47	351873.502	716058.357	1.915
351885.864	715998.025	3.206	351970.978	716004.616	0.528	352097.691	715985.119	-1.77	351862.105	716084.664	1.946
351882.776	715994.174	3.478	351958.7	715996.631	0.666	352109.528	715991.52	-2.21	351853.616	716105.312	1.951
351884.7	715987.529	3.692	351946.55	715988.133	0.879	352116.788	715974.499	-1.73	351845.931	716127.132	1.919
351889.497	715979.406	3.678	351936.876	715980.201	1.235	352121.628	715959.462	-1.36	351838.059	716148.026	1.912
351894.864	715971.366	3.663	351928.306	715973.601	1.566	352113.093	715944.765	-0.9	351829.561	716177.875	1.817
351900.371	715963.999	3.664	351923.397	715970.204	1.899	352107.421	715936.744	-0.47	351820.292	716204.271	1.783
351906.054	715955.94	3.709	351918.87	715966.557	2.633	352099.566	715925.777	0.023	351812.908	716225.834	1.766
351911.85	715949.13	3.635	351915.142	715963.728	3.026	352092.755	715917.212	0.224	351802.536	716252.113	1.865
351917.124	715942.612	3.622	351911.641	715960.769	3.234	352085.676	715908.556	0.409	351795.492	716270.717	1.784
351920.521	715938.287	3.65	351908.358	715957.871	3.345	352072.694	715899.503	0.776	351779.113	716279.621	3.138
351925.865	715942.088	3.176	351920.668	715956.542	2.895	352066.03	715886.445	0.857	351767.305	716277.701	3.525
351931.649	715946.034	2.883	351931.513	715947.287	2.862	352062.452	715874.926	1.191			

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351766.493	716340.675	2.179	351858.432	716572.015	-1.5	351752.473	716479.111	0.842	351723.525	716392.453	4.011	351753.271	716354.65	2.507
351759.646	716361.758	2.099	351869.923	716569.987	-1.6	351763.881	716481.72	0.613	351728.334	716394.053	3.378	351747.671	716352.827	3.196
351752.044	716382.939	2.124	351884.782	716568.632	-1.79	351774.737	716484.18	0.281	351733.464	716395.877	3.024	351743.44	716350.375	3.615
351744.869	716402.085	2.122	351879.136	716552.772	-1.68	351782.931	716485.933	0.005	351739.134	716397.844	2.517	351740.585	716349.045	4.211
351737.251	716421.755	2.088	351864.575	716545.964	-1.59	351790.194	716487.257	-0.11	351743.297	716399.426	2.318	351743.236	716342.501	4.058
351729.989	716442.936	2.047	351852.702	716544.348	-1.45	351798.661	716488.529	-0.5	351747.539	716399.8	1.937	351744.671	716338.965	4.01
351724.093	716464.532	2.009	351838.855	716542.937	-1.22	351805.477	716489.461	-0.99	351752.154	716400.436	1.393	351747.151	716332.66	3.999
351720.002	716481.902	2.047	351828.067	716539.258	-1.12	351816.899	716491.214	-1.26	351759.069	716401.607	1.154	351750.289	716323.733	3.974
351716.942	716499.061	2.131	351812.688	716535.433	-0.9	351827.237	716492.653	-1.41	351768.291	716404.141	0.914	351753.938	716313.734	3.994
351715.081	716518.22	2.14	351796.014	716533.78	-0.52	351838.391	716494.59	-1.47	351777.259	716406.424	0.846	351758	716314.925	3.475
351714.615	716537.247	2.18	351788.524	716532.431	-0.33	351850.518	716496.602	-1.53	351787.318	716409.325	0.638	351763.105	716316.671	3.072
351710.405	716545.376	2.333	351777.206	716530.291	0.101	351861.417	716497.886	-1.54	351799.808	716413.399	0.291	351767.494	716318.199	2.472
351703.325	716552.256	2.728	351765.166	716528.535	0.58	351873.625	716498.047	-1.66	351811.21	716416.704	-0.13	351772.074	716319.798	2.431
351677.915	716578.793	3.788	351752.455	716526.818	0.874	351886.707	716498.105	-1.82	351822.779	716420.531	-0.63	351777.063	716321.577	1.728
351679.175	716575.156	3.476	351741.007	716525.431	1.081	351887.679	716477.95	-1.91	351833.123	716424.189	-1.12	351786.566	716324.471	1.405
351685.505	716574.625	3.205	351731.031	716524.681	1.33	351875.464	716474.215	-1.81	351843.137	716427.675	-1.5	351798.678	716328.295	0.87
351694.163	716574.532	3.033	351721.936	716524.131	1.683	351861.85	716470.005	-1.7	351848.74	716429.25	-1.76	351810.515	716331.817	0.615
351701.725	716574.106	2.774	351716.118	716523.474	2.036	351851.436	716468.61	-1.78	351869.295	716431.979	-1.71	351820.932	716335.038	0.537
351709.349	716576.112	2.334	351710.439	716522.874	2.388	351838.006	716466.011	-1.68	351880.98	716432.532	-1.5	351832.424	716338.381	0.297
351715.202	716576.484	2.307	351704.217	716521.644	2.733	351824.92	716463.563	-1.47	351892.88	716434.479	-1.55	351843.864	716341.443	0.034
351718.409	716576.454	2.118	351696.887	716520.22	3.147	351813.562	716461.093	-1.01	351910.944	716425.007	-1.51	351858.223	716345.207	-0.2
351726.969	716577.052	1.67	351691.781	716518.906	3.345	351800.827	716458.422	-0.27	351898.441	716418.905	-1.42	351871.281	716348.846	-0.47
351736.256	716577.493	1.408	351687.172	716517.85	3.973	351786.657	716454.11	0.121	351883.785	716413.778	-1.38	351883.717	716353.516	-0.75
351744.899	716577.298	1.172	351689.475	716507.866	3.928	351773.552	716450.12	0.552	351870.615	716407.801	-1.33	351890.847	716355.485	-0.81
351752.114	716577.695	0.986	351697.332	716502.454	3.215	351760.103	716445.33	0.854	351862.198	716404.013	-1.26	351898.665	716357.518	-1.18
351760.583	716577.769	0.749	351699.023	716493.007	3.269	351748.913	716442.146	1.082	351853.881	716399.986	-1	351911.135	716360.289	-1.34
351768.391	716577.43	0.361	351692.537	716489.071	3.882	351736.713	716439.184	1.403	351842.892	716394.93	-0.6	351931.902	716364.766	-1.63
351775.811	716577.458	0.003	351694.903	716476.135	3.851	351731.387	716437.323	2.075	351827.51	716388.941	-0.23	351954.956	716369.111	-1.83
351784.904	716577.235	-0.46	351698.883	716467.053	3.708	351722.471	716434.091	2.729	351812.385	716381.734	0.301	351976.245	716371.993	-1.95
351792.693	716577.318	-0.78	351703.802	716468.254	3.344	351716.45	716432.695	3.308	351800.687	716375.746	0.628	351978.208	716363.388	-1.96
351801.774	716578.407	-0.95	351708.584	716469.024	3.126	351709.416	716430.319	4.031	351788.532	716370.237	0.795	351956.663	716353.579	-1.79
351806.618	716577.466	-0.78	351714.258	716470.385	2.554	351704.848	716442.357	3.931	351778.785	716365.497	0.973	351937.488	716346.187	-1.62
351814.872	716576.535	-0.85	351719.8	716471.528	2.275	351711.608	716444.861	3.312	351778.801	716365.398	0.954	351919.517	716339.006	-1.33
351824.533	716575.503	-1.01	351724.214	716472.595	1.794	351720.675	716423.699	3.232	351770.34	716361.071	1.294	351911.307	716335.303	-1.18
351834.727	716574.652	-1.2	351728.494	716473.738	1.444	351713.673	716418.639	4.064	351765.388	716358.972	1.551	351900.955	716330.544	-0.83
351845.082	716573.418	-1.37	351740.354	716476.162	1.126	351718.324	716406.25	4.045	351760.073	716357.583	2.158	351883.896	716323.514	-0.45

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351869.445	716317.026	-0.13	351995.778	716294.395	-2.18	351900.392	716195.65	0.057	351864.137	716095.384	1.647	351895.259	716014.232	2.362
351852.676	716310.006	0.204	351985.561	716284.407	-2.09	351912.746	716201.973	-0.2	351879.969	716102.591	1.089	351900.316	716017.636	1.629
351832.848	716301.265	0.463	351971.713	716277.274	-1.9	351926.569	716209.461	-0.64	351895.524	716109.45	0.749	351911.621	716025.3	1.18
351819.639	716295.412	0.687	351961.277	716272.272	-1.64	351936.47	716214.198	-0.94	351909.168	716116.021	0.466	351926.393	716034.503	0.79
351812.677	716292.264	0.869	351956.82	716270.388	-1.83	351946.292	716219.424	-1.37	351925.708	716124.437	0.117	351945.214	716045.496	0.463
351803.898	716288.106	1.418	351944.862	716264.146	-1.6	351956.66	716225.039	-1.7	351939.518	716130.7	-0.22	351964.37	716054.106	-0
351795.293	716283.917	1.683	351933.369	716258.471	-1.18	351968.414	716231.291	-1.87	351953.458	716138.421	-0.63	351977.113	716060.764	-0.42
351790.623	716281.701	1.787	351920.159	716252.783	-0.7	351979.923	716237.54	-2.03	351962.382	716142.244	-0.8	351990.699	716068.06	-0.87
351786.386	716279.763	2.442	351902.093	716245.263	-0.25	351990.213	716242.43	-2.11	351972.464	716147.861	-1.31	352004.352	716074.037	-1.34
351782.619	716277.85	2.652	351886.558	716239.159	0.065	352001.911	716246.316	-2.16	351982.341	716152.712	-1.58	352014.563	716079.517	-1.73
351778.773	716276.056	3.253	351870.678	716231.779	0.347	352007.669	716228.589	-2.21	351992.637	716157.667	-1.65	352018.543	716093.198	-1.79
351771.214	716272.195	3.483	351854.955	716225.084	0.601	351996.441	716218.986	-1.98	352003.912	716163.178	-1.86	352026.621	716087.37	-1.8
351773.374	716264.434	3.815	351840.786	716218.629	1.032	351983.454	716211.336	-1.87	352021.225	716170.524	-2.15	352034.021	716091.394	-1.8
351777.655	716253.747	3.801	351830.981	716213.655	1.371	351968.944	716203.313	-1.65	352025.959	716153.929	-2.16	352045.58	716096.988	-2.12
351780.856	716244.788	3.788	351821.671	716209.009	1.672	351955.004	716195.193	-1.31	352032.272	716135.261	-2.18	352054.479	716080.184	-2.11
351783.603	716238.032	3.775	351816.048	716206.572	2.309	351940.336	716185.019	-0.65	352019.49	716126.77	-1.89	352041.359	716069.186	-1.68
351787.714	716239.546	3.343	351811.296	716204.305	2.517	351926.014	716175.292	-0.25	352001.281	716116.409	-1.64	352025.51	716055.317	-1.48
351787.72	716239.537	3.353	351806.681	716202.48	3.175	351911.208	716165.659	0.108	351988.767	716111.102	-1.4	352011.704	716043.812	-1.12
351792.97	716241.492	3.11	351802.061	716201.16	3.392	351896.668	716157.904	0.405	351978.651	716106.633	-0.97	351995.782	716029.986	-0.41
351800.578	716244.628	2.352	351796.965	716201.918	3.928	351882.873	716151.016	0.665	351967.913	716101.697	-0.65	351982.064	716017.807	0.12
351804.873	716246.353	1.788	351796.868	716201.864	3.933	351869.278	716144.841	1.019	351951.224	716093.174	-0.15	351968.243	716008.666	0.522
351814.709	716250.502	1.457	351813.755	716196.833	2.53	351857.396	716138.562	1.394	351931.324	716084.722	0.31	351950.493	715996.653	0.834
351824.529	716255.387	1.045	351820.983	716187.447	2.382	351848.867	716134.657	1.622	351909.928	716076.027	0.707	351937.845	715988.124	1.027
351833.788	716259.915	0.664	351825.03	716176.688	2.409	351843.203	716131.835	2.29	351893.006	716067.611	1.143	351927.27	715981.611	1.384
351846.62	716265.978	0.444	351819.239	716167.28	3.018	351837.376	716128.67	2.498	351881.907	716062.714	1.54	351922.25	715978.196	1.985
351857.538	716271.112	0.32	351814.081	716162.997	3.454	351832.475	716126.296	3.15	351878.711	716061.043	1.638	351919.361	715976.069	2.431
351867.004	716275.652	0.178	351811.365	716161.744	3.702	351828.528	716124.526	3.411	351872.788	716058.368	2.313	351913.684	715971.727	2.452
351883.417	716282.506	-0.16	351814.205	716153.675	3.748	351825.347	716123.038	3.775	351865.232	716054.276	2.72	351907.121	715967.703	3.239
351897.306	716288.171	-0.43	351818.908	716156.259	3.322	351828.97	716112.861	3.742	351859.726	716051.229	3.275	351900.098	715964.305	3.724
351909.659	716293.213	-0.74	351824.229	716158.886	2.782	351832.725	716102.941	3.816	351854.845	716048.291	3.738	351907.1	715954.87	3.717
351918.574	716296.621	-1	351830.955	716161.915	2.314	351832.672	716102.822	3.81	351860.806	716035.501	3.681	351913.53	715946.92	3.75
351927.349	716300.637	-1.34	351837.115	716164.62	1.671	351836.541	716093.354	3.762	351866.324	716023.293	3.632	351920.513	715938.513	3.703
351941.472	716306.799	-1.56	351848.644	716169.911	1.279	351839.595	716085.181	3.767	351871.59	716013.859	3.48	351928.7	715943.762	3.107
351956.291	716312.871	-1.79	351861.756	716176.346	0.845	351845.2	716087.632	3.288	351877.199	716003.298	3.652	351934.605	715947.606	2.388
351973.336	716318.675	-1.99	351876.016	716183.692	0.515	351852.082	716090.36	2.526	351884.976	716007.789	3.183	351939.283	715950.925	2.33
351995.896	716321.173	-2.18	351887.362	716189.502	0.333	351858.474	716092.855	2.273	351890.424	716011.137	2.435	351945.037	715954.957	1.525

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H	V	D	H	V	D	H	V	D	H	V	D
351954.476	715962.214	1.169	352049.587	715930.687	0.51	351896.591	716000.516	2.422	351776.259	716303.449	2.44
351967.918	715971.968	0.965	352055.567	715941.793	0.227	351883.79	716023.525	2.45	351769.327	716301.156	3.115
351977.542	715979.441	0.795	352062.949	715953.721	-0.25	351884.949	716033.668	2.28	351763.437	716299.278	3.489
351991.823	715987.444	0.425	352071.721	715964.261	-0.77	351889.691	716037.521	1.613	351758.769	716300.342	3.946
352003.317	715995.666	0.042	352080.056	715973.8	-1.16	351881.121	716056.183	1.611	351761.793	716291.558	3.896
352013.822	716004.505	-0.33	352088.914	715981.922	-1.46	351875.048	716057.835	2.175	351765.052	716283.317	3.729
352022.804	716010.422	-0.79	352096.404	715986.385	-1.76	351867.074	716060.349	2.422			
352033.317	716018.57	-1.28	352109.409	715976.812	-1.71	351850.477	716098.604	2.453			
352042.498	716023.776	-1.41	352117.616	715963.87	-1.38	351853.01	716106.041	2.274			
352050.56	716029.205	-1.43	352126.316	715946.263	-0.98	351856.502	716113.731	1.699			
352065.313	716037.192	-2.06	352128.103	715932.637	-0.54	351850.898	716128.816	1.639			
352075.843	716027.801	-2.12	352124.493	715920.616	-0.12	351846.111	716129.582	2.145			
352069.175	716017.915	-1.84	352119.813	715911.382	0.221	351838.884	716128.635	2.466			
352059.34	716008.323	-1.51	352112.407	715902.101	0.501	351833.73	716140.613	2.474			
352048.946	715999.263	-1.36	352108.041	715938.345	-0.48	351837.508	716147.161	2.272			
352041.314	715992.226	-1.09	352094.001	715928.85	-0.02	351841.728	716154.591	1.531			
352034.517	715985.328	-0.41	352085.264	715916.635	0.465	351834.948	716171.482	1.647			
352021.842	715971.35	0.147	352074.147	715903.611	0.638	351829.34	716186.412	1.65			
352007.985	715958.405	0.662	352068.466	715894.494	0.844	351822.492	716185.447	2.322			
351994.198	715946.228	0.935	352061.892	715879.431	1.151	351820.986	716196.009	2.185			
351982.751	715935.44	1.231	352055.451	715871.522	1.389	351822.733	716202.285	1.729			
351970.413	715924.555	1.743	352053.548	715863.28	1.807	351817.078	716217.113	1.717			
351965.777	715918.291	2.358	352053.3	715862.405	1.905	351810.376	716219.51	2.344			
351961.143	715913.02	2.586	352052.407	715854.608	2.81	351804.708	716220.719	2.553			
351956.541	715907.262	3.023	352039.985	715858.011	2.838	351801.313	716230.864	2.563			
351953.965	715904.388	3.368	352038.026	715866.511	2.175	351803.988	716235.265	2.363			
351967.001	715894.322	3.332	352022.093	715865.055	2.773	351806.708	716241.287	1.782			
351981.011	715885.619	3.128	352021.53	715872.053	2.312	351801.731	716254.155	1.83			
351989.429	715880.508	2.886	352004.876	715909.695	1.37	351795.683	716255.172	2.414			
352000.727	715874.246	3.039	351970.918	715931.652	1.546	351788.657	716265.982	2.555			
352005.283	715880.507	2.284	351958.886	715935.152	1.74	351790.897	716270.552	2.331			
352010.832	715884.562	2.067	351948.773	715938.171	2.316	351794.192	716272.457	1.808			
352015.998	715896.402	1.378	351932.148	715957.819	2.342	351789.623	716285.082	1.78			
352028.321	715904.072	0.956	351931.731	715973.397	1.452	351786.21	716296.439	1.704			
352035.465	715913.75	0.662	351916.331	715994.181	1.512	351781.141	716309.868	1.8			
352042.124	715919.825	0.79	351907.449	715992.444	2.339	351774.671	716311.739	2.434			

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East Sands

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351752.634	716313.027	4.296	351794.211	716571.579	-0.75	351720.51	716472.296	1.934	351714.34	716430.094	3.412	351762.334	716370.339	1.465
351752.733	716317	3.813	351802.992	716571.593	-0.82	351726.131	716473.571	1.505	351710.729	716428.519	3.845	351755.352	716366.956	1.987
351750.433	716323.452	3.79	351811.816	716571.669	-0.98	351732.992	716475.291	1.061	351722.015	716419.362	3.168	351750.188	716364.831	2.609
351747.262	716332.586	3.823	351821.322	716571.434	-1.11	351740.217	716476.643	0.942	351725.249	716404.91	3.262	351746.187	716362.845	2.938
351743.672	716341.828	3.861	351829.752	716571.489	-1.25	351747.558	716478.355	0.871	351723.367	716392.487	3.95	351741.655	716360.458	3.381
351738.91	716353.973	3.94	351837.926	716571.383	-1.38	351755.397	716480.149	0.752	351727.423	716393.763	3.418	351737.611	716358.308	3.865
351733.488	716367.522	3.853	351843.234	716543.242	-1.39	351762.973	716481.462	0.558	351731.984	716395.315	3.116	351747.052	716353.084	3.178
351728.092	716381.042	3.937	351826.801	716541.977	-1.21	351769.74	716483.04	0.33	351736.357	716397.366	2.714	351753.12	716341.354	3.074
351722.805	716394.705	3.898	351816.894	716533.698	-1.08	351777	716484.483	0.115	351741.411	716399.664	2.064	351756.739	716327.76	3.194
351717.519	716408.527	3.966	351807.002	716531.235	-0.99	351784.425	716486.384	-0.14	351747.593	716402.115	1.542	351754.197	716313.906	3.757
351710.942	716426.437	3.9	351796.687	716528.53	-0.9	351791.547	716488.145	-0.45	351755.087	716405.163	1.036	351758.866	716315.847	3.39
351705.104	716442.856	3.832	351789.011	716526.83	-0.51	351798.083	716490.145	-0.72	351762.534	716408.282	0.921	351764.052	716317.972	2.798
351696.574	716470.834	3.865	351779.809	716524.878	-0.14	351805.267	716492.01	-1.07	351770.637	716411.532	0.816	351769.148	716320.307	2.478
351693.82	716482.385	3.735	351771.521	716523.453	0.16	351812.78	716494.061	-1.31	351778.783	716414.738	0.663	351776.628	716323.362	1.712
351692.367	716495.442	3.621	351764.316	716521.555	0.452	351823.392	716495.008	-1.45	351787.477	716417.887	0.5	351784.479	716326.662	1.228
351690.311	716507.56	3.659	351756.995	716520.024	0.704	351834.557	716496.749	-1.55	351795.993	716420.984	0.241	351789.855	716328.823	0.965
351687.973	716521.351	3.647	351749.027	716518.273	0.863	351846.107	716497.983	-1.59	351804.999	716424.578	-0.13	351799.301	716332.954	0.848
351686.269	716534.702	3.592	351741.008	716517.206	0.97	351860.392	716499.054	-1.69	351812.357	716427.796	-0.47	351810.503	716337.473	0.646
351678.014	716578.922	3.732	351733.064	716515.651	1.094	351876.275	716498.153	-1.8	351820.383	716430.928	-0.86	351821.249	716342.015	0.403
351678.954	716576.55	3.28	351726.774	716514.674	1.286	351866.832	716477.837	-1.82	351828.725	716434.804	-1.32	351829.414	716345.899	0.232
351686.472	716575.941	3.046	351721.258	716513.785	1.574	351856.042	716474.372	-1.73	351836.428	716438.955	-1.64	351838.751	716349.434	0.031
351693.159	716575.944	2.941	351716.328	716513.239	1.943	351845.3	716471.049	-1.72	351842.752	716442.299	-1.85	351846.692	716352.843	-0.14
351701.01	716575.64	2.742	351712.07	716512.621	2.373	351831.916	716466.863	-1.68	351909.824	716430.564	-1.85	351855.893	716356.697	-0.35
351706.78	716575.701	2.611	351707.275	716511.951	2.691	351821.539	716463.903	-1.5	351895.314	716424.325	-1.59	351865.501	716361.081	-0.59
351710.687	716575.28	2.452	351701.913	716511.179	2.978	351810.661	716460.7	-0.88	351880.84	716419.617	-1.48	351874.542	716365.043	-0.9
351715.089	716574.846	2.139	351695.771	716510.232	3.18	351801.602	716457.905	-0.51	351869.236	716415.261	-1.5	351886.197	716370.497	-1.33
351722.237	716574.503	1.732	351691.324	716509.494	3.493	351791.108	716455.359	-0.09	351857.478	716410.869	-1.5	351897.78	716376.073	-1.44
351729.854	716574.337	1.476	351689.081	716508.805	3.897	351781.003	716452.249	0.255	351845.57	716406.157	-1.32	351910.253	716380.461	-1.49
351737.48	716574.091	1.287	351700.973	716499.147	3.051	351770.039	716449.24	0.602	351834.964	716401.663	-0.75	351924.884	716383.185	-1.62
351744.508	716573.896	1.142	351708.197	716491.782	2.785	351760.298	716446.399	0.765	351823.855	716397.467	-0.25	351944.53	716386.338	-1.75
351751.532	716574.027	1.009	351703.632	716479.188	3.113	351751.536	716443.648	0.931	351814.84	716393.527	0.094	351962.502	716364.316	-1.91
351758.052	716573.001	0.681	351699.05	716466.866	3.588	351743.034	716441.009	1.075	351805.646	716389.582	0.356	351948.037	716358.303	-1.8
351763.482	716572.82	0.364	351701.072	716467.519	3.43	351735.992	716438.599	1.427	351796.335	716385.631	0.533	351935.073	716352.699	-1.67
351770.534	716572.358	-0.01	351705.046	716468.521	3.198	351730.078	716436.506	1.851	351785.515	716381.454	0.748	351924.396	716347.844	-1.54
351776.196	716572.044	-0.31	351710.269	716469.769	2.87	351724.551	716434.474	2.497	351777.535	716377.666	0.847	351912.756	716342.182	-1.35
351781.549	716571.588	-0.62	351714.8	716470.97	2.571	351719.905	716432.676	3.015	351769.634	716373.879	1.106	351903.772	716337.936	-1.24

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351892.613	716333.036	-0.85	351900.88	716289.286	-0.58	351841.912	716164.758	1.659	351824.518	716125.251	3.688	351887.584	716058.65	1.466
351878.111	716326.763	-0.43	351908.817	716292.259	-0.92	351850.577	716168.525	1.178	351827.474	716117.171	3.663	351880.478	716055.137	1.961
351865.406	716321.498	-0.17	351917.611	716295.283	-1.27	351860.4	716172.883	0.822	351830.573	716109.167	3.589	351876.083	716053.098	2.382
351853.687	716315.588	0.099	351927.464	716298.249	-1.48	351869.807	716177.391	0.635	351833.765	716101.043	3.664	351870.61	716050.575	2.391
351840.44	716309.338	0.365	351937.414	716301.156	-1.61	351881.458	716182.386	0.448	351837.562	716091.123	3.617	351865.848	716048.309	3.022
351828.262	716303.895	0.584	351953.249	716303.91	-1.82	351890.811	716186.378	0.269	351839.6	716085.431	3.642	351860.655	716045.252	3.3
351817.014	716297.811	0.744	351964.309	716273.908	-1.84	351900.852	716191.006	0.096	351845.898	716087.448	3.173	351856.988	716043.303	3.644
351808.555	716293.761	0.93	351955.509	716267.603	-1.7	351908.718	716194.939	-0.06	351851.49	716089.542	2.619	351861.499	716034.052	3.595
351800.83	716289.85	1.261	351946.356	716263.201	-1.58	351916.325	716198.061	-0.24	351855.513	716091.232	2.262	351867.181	716021.546	3.41
351795.073	716286.583	1.72	351937.152	716258.712	-1.47	351925.126	716201.785	-0.68	351860.374	716092.781	2.326	351871.85	716013.214	3.372
351790.703	716284.471	2.068	351927.569	716254.522	-1.32	351934.907	716205.777	-1.09	351868.387	716095.409	1.654	351877.273	716003.192	3.563
351786.658	716282.148	2.496	351917.225	716249.484	-0.93	351944.305	716209.918	-1.43	351876.635	716098.297	1.149	351882.182	716006.218	3.204
351781.833	716279.151	2.552	351907.095	716244.111	-0.45	351954.311	716214.417	-1.62	351886.325	716101.649	0.946	351886.017	716008.555	2.985
351778.059	716276.878	3.118	351895.141	716239.746	-0.01	351964.532	716218.499	-1.78	351897.32	716105.8	0.679	351889.32	716010.917	2.541
351772.807	716273.805	3.296	351882.853	716234.522	0.115	351974.544	716222.081	-1.88	351909.041	716109.788	0.416	351895.097	716014.969	2.341
351770.59	716272.591	3.377	351871.312	716229.818	0.324	351986.871	716201.194	-1.9	351919.476	716113.166	0.241	351902.352	716019.638	1.707
351773.862	716263.927	3.664	351862.435	716225.931	0.446	351979.707	716196.208	-1.76	351930.235	716116.745	0.049	351909.407	716023.788	1.091
351776.932	716256.412	3.588	351851.019	716221.385	0.692	351970.794	716191.251	-1.62	351940.338	716120.258	-0.07	351919.795	716029.447	0.994
351780.76	716246.306	3.597	351841.006	716216.879	0.854	351960.954	716185.384	-1.48	351950.257	716123.893	-0.46	351932.634	716036.599	0.671
351783.421	716238.078	3.637	351832.701	716212.533	1.236	351950.882	716179.952	-1.27	351960.287	716127.469	-0.9	351943.488	716042.699	0.408
351786.847	716239.663	3.39	351825.168	716208.83	1.727	351941.498	716175.296	-0.9	351970.405	716132.17	-1.26	351952.987	716048.95	0.256
351792.183	716242.29	3.113	351819.578	716206.709	2.198	351931.763	716171.316	-0.49	351979.567	716135.257	-1.32	351963.329	716054.855	0.074
351796.494	716244.114	2.534	351814.297	716204.181	2.401	351920.66	716166.765	-0.03	351997.065	716142.667	-1.65	351972.082	716059.99	-0.28
351800.414	716246.187	2.423	351809.92	716202.437	2.657	351910.013	716162.607	0.322	352010.109	716128.9	-1.82	351978.92	716064.043	-0.56
351804.233	716247.781	2.402	351805.061	716199.886	3.208	351905.101	716160.693	0.363	351999.12	716117.883	-1.52	351988.305	716068.35	-1.04
351811.247	716250.55	1.641	351798.752	716197.023	3.831	351894.458	716155.914	0.37	351990.306	716112.375	-1.34	351999.471	716074.536	-1.27
351818.749	716253.888	1.144	351801.928	716188.5	3.727	351882.962	716150.923	0.587	351979.594	716104.296	-1.14	352010.267	716080.674	-1.45
351828.216	716258.134	0.723	351806.353	716178.728	3.572	351870.688	716145.598	0.873	351971.698	716099.875	-0.92	352024.425	716089.108	-1.77
351837.731	716262.268	0.59	351809.971	716166.62	3.605	351861.277	716142.039	1.028	351961.268	716094.335	-0.42	352032.155	716069.626	-1.7
351847.521	716266.54	0.439	351813.143	716157.58	3.617	351854.029	716139.112	1.461	351948.835	716088.038	0.035	352020.165	716057.875	-1.36
351857.792	716270.813	0.226	351814.318	716153.839	3.664	351848.143	716136.401	1.929	351937.589	716082.443	0.181	352009.931	716049.144	-1.19
351868.721	716275.871	0.104	351818.169	716155.648	3.305	351843.949	716134.703	2.364	351925.125	716076.488	0.429	352000.527	716041.247	-0.8
351877.976	716279.357	-0.05	351822.154	716157.28	3.029	351838.124	716131.676	2.357	351913.616	716071.774	0.696	351991.6	716033.452	-0.37
351884.586	716282.836	-0.13	351826.714	716159.161	2.472	351833.819	716129.435	2.829	351904.841	716067.618	0.878	351983.001	716026.926	-0.14
351892.204	716285.691	-0.27	351833.391	716161.378	2.184	351827.147	716126.265	3.39	351894.807	716062.222	0.968	351974.965	716020.753	0.113

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351965.801	716014.061	0.375	352047.836	716012.269	-1.47	352090.001	715992.914	-1.69	351796.759	716257.532	2.439
351955.554	716006.816	0.64	352042.917	716004.545	-1.36	352094.02	715997.632	-1.94			
351945.164	715999.389	0.877	352036.345	715996.405	-0.96	352106.603	715988.233	-1.91			
351934.606	715992.211	1.085	352029.454	715988.2	-0.52	352107.666	715976.495	-1.61			
351928.137	715987.689	1.242	352023.011	715980.216	-0.18	352104.197	715967.985	-1.37			
351922.663	715984.056	1.715	352017.223	715972.104	0.098	352100.529	715957.605	-1.09			
351917.496	715979.896	2.206	352011.794	715964.025	0.355	352095.629	715947.306	-0.67			
351913.739	715976.757	2.68	352005.17	715954.423	0.623	352107.965	715931.037	-0.34			
351909.971	715973.801	2.697	351998.917	715944.326	0.868	352088.133	715927.068	-0.01			
351904.699	715970.171	3.214	351992.604	715933.629	1.016	352080.405	715916.04	0.299			
351901.542	715967.557	3.345	351984.86	715924.083	1.292	352072.311	715904.659	0.467			
351899.32	715965.345	3.661	351980.008	715917.325	1.736	352069.66	715895.821	0.774			
351905.192	715957.334	3.634	351975.233	715910.932	2.177	352061.665	715882.256	1.048			
351911.62	715949.393	3.611	351970.956	715905.394	2.429	352056.073	715871.914	1.377			
351916.583	715943.575	3.554	351967.928	715900.641	2.863	352054.629	715863.868	1.847			
351920.307	715938.507	3.602	351965.764	715896.885	3.126	352054.376	715862.743	1.955			
351924.22	715941.56	3.193	351964.375	715895.145	3.429	352053.069	715856.625	2.401			
351928.905	715945.161	2.947	351970.363	715891.349	3.277	352052.203	715852.888	2.948			
351932.107	715947.367	2.485	351976.413	715887.835	3.126	352032.243	715867.824	2.119			
351934.869	715949.52	2.498	351981.356	715891.419	2.516	352019.51	715873.954	2.213			
351939.889	715953.565	2.064	351994.969	715877.33	2.869	351997.764	715887.849	2.099			
351946.567	715959.088	1.461	352000.845	715874.04	2.963	351990.029	715902.497	1.89			
351952.368	715964.32	1.094	352003.997	715878.179	2.432	351976.261	715914.403	1.993			
351961.01	715971.815	0.995	352009.953	715884.409	1.932	351950.607	715936.029	2.377			
351969.677	715979.26	0.803	352020.279	715891.922	1.359	351929.976	715955.782	2.585			
351978.399	715987.175	0.544	352026.996	715899.926	1.059	351918.385	715973.355	2.483			
351986.853	715994.737	0.292	352034.603	715911.941	0.887	351903.937	715995.395	2.547			
351995.487	716002.691	0.027	352040.496	715919.986	0.713	351883.159	716039.035	2.458			
352002.971	716009.377	-0.26	352045.398	715926.808	0.536	351874.101	716058.437	2.414			
352010.045	716015.45	-0.57	352051.536	715935.357	0.288	351864.098	716077.908	2.166			
352016.614	716021.091	-0.91	352058.318	715945.488	-0.06	351856.9	716101.984	2.372			
352025.107	716028.469	-1.26	352063.582	715953.743	-0.37	351846.538	716125.065	2.316			
352035.048	716036.007	-1.44	352068.701	715961.222	-0.68	351837.657	716148.94	2.385			
352047.756	716045.668	-1.73	352074.026	715969.76	-1.04	351829.911	716172.474	2.378			
352059.186	716028.315	-1.75	352079.25	715977.212	-1.26	351814.806	716213.992	2.435			
352053.996	716019.719	-1.55	352085.049	715985.613	-1.49	351803.473	716244.54	2.462			

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351765.653	716282.462	3.731	351790.479	716574.191	-0.51	351724.402	716471.532	1.792	351729.782	716407.019	2.706	351738.788	716353.726	3.911
351762.186	716290.852	3.904	351801.521	716573.796	-0.66	351733.897	716473.392	1.254	351725.125	716400.236	3.27	351747.946	716349.833	3.019
351757.139	716304.383	3.95	351814.16	716572.811	-0.91	351746.232	716475.813	1.038	351723.313	716392.575	3.888	351755.484	716347.058	2.469
351750.985	716321.956	3.838	351825.177	716572.572	-1.1	351756.507	716477.86	0.911	351728.514	716394.021	3.138	351762.954	716343.015	2.029
351746.276	716335.177	3.894	351841.365	716572.326	-1.3	351765.706	716479.884	0.656	351735.897	716395.857	2.554	351759.484	716332.618	2.658
351741.533	716346.506	4.048	351857.808	716572.632	-1.43	351775.347	716481.953	0.391	351745.623	716398.067	1.888	351755.764	716324.162	3.202
351737.54	716357.691	3.889	351869.697	716571.365	-1.58	351785.032	716483.575	0.102	351756.886	716401.099	1.408	351753.609	716313.656	3.841
351732.13	716370.961	3.866	351883.434	716571.15	-1.84	351794.813	716485.397	-0.39	351767.022	716403.785	0.994	351758.194	716315.362	3.294
351726.946	716383.654	3.858	351879.901	716543.858	-1.7	351804.492	716486.775	-0.9	351780.696	716407.33	0.753	351766.033	716318.206	2.558
351722.972	716393.948	3.871	351864.696	716544.312	-1.56	351815.123	716488.414	-1.25	351791.122	716410.157	0.572	351775.161	716321.723	1.927
351718.221	716406.176	3.873	351855.379	716533.801	-1.48	351828.007	716490.503	-1.42	351801.647	716413.53	0.408	351787.162	716326.358	1.447
351713.08	716420.276	3.928	351846.746	716529.383	-1.34	351838.393	716492.511	-1.5	351812.667	716416.914	-0.14	351799.046	716331.266	0.871
351707.176	716435.867	4.012	351831.669	716526.299	-1.2	351852.211	716495.152	-1.57	351825.006	716420.781	-0.79	351811.919	716336.619	0.678
351701.712	716451.228	3.925	351817.171	716524.301	-1.1	351863.195	716497.034	-1.65	351837.552	716424.654	-1.38	351823.569	716341.476	0.602
351696.413	716469.291	4.004	351803.236	716521.596	-0.95	351880.666	716499.25	-1.75	351852.575	716428.61	-1.63	351834.754	716345.623	0.393
351693.26	716482.923	3.916	351793.529	716520.681	-0.59	351877.972	716487.025	-1.81	351867.068	716432.159	-1.71	351844.936	716349.283	0.13
351690.368	716496.781	3.954	351780.415	716519.821	0.05	351872.47	716475.18	-1.83	351884.483	716435.557	-1.71	351856.006	716353.202	-0.16
351689.266	716509.405	3.909	351767.242	716518.467	0.522	351867.994	716460.759	-1.85	351898.031	716438.506	-1.63	351866.419	716356.778	-0.5
351686.331	716518.352	4.063	351754.277	716518.02	0.867	351853.067	716456.243	-1.71	351913.269	716442.255	-1.63	351876.12	716360.673	-0.97
351683.668	716533.464	3.93	351739.556	716517.714	1.102	351841.358	716454.446	-1.66	351927.48	716438.194	-1.85	351885.215	716363.984	-1.17
351695.587	716541.777	3.003	351727.782	716516.632	1.509	351832.274	716452.191	-1.53	351934.342	716422.619	-1.86	351893.801	716367.216	-1.22
351698.653	716556.738	2.828	351717.634	716516.079	1.919	351820.486	716451.151	-1.15	351916.775	716415.392	-1.53	351903.644	716370.542	-1.29
351696.524	716571.102	2.87	351711.943	716515.551	2.292	351809.461	716449.259	-0.57	351899.845	716409.87	-1.32	351919.049	716373.223	-1.42
351677.831	716578.916	3.816	351707.216	716515.089	2.667	351798.159	716448.116	0.004	351881.037	716403.337	-1.19	351937.698	716377.957	-1.58
351678.304	716577.453	3.297	351701.653	716514.867	2.861	351781.085	716445.502	0.494	351866.889	716397.494	-1.19	351955.957	716384.231	-1.72
351686.262	716575.828	3.174	351694.728	716513.711	3.29	351766.075	716443.401	0.844	351853.766	716393.635	-1.12	351966.442	716386.101	-1.84
351696.005	716574.861	2.837	351689.638	716512.56	3.717	351752.409	716441.28	0.995	351843.14	716390.24	-0.6	351967.343	716369.373	-1.85
351704.472	716574.726	2.539	351699.091	716508.11	3.028	351743.26	716439.542	1.272	351829.486	716385.796	-0.11	351955.468	716363.947	-1.73
351710.343	716574.532	2.605	351706.634	716501.41	2.707	351735.599	716437.883	1.656	351815.176	716380.982	0.4	351941.385	716358.219	-1.63
351717.824	716574.125	2.023	351714.453	716494.244	2.123	351727.606	716434.791	2.009	351804.204	716376.46	0.736	351927.519	716353.002	-1.44
351730.821	716573.785	1.557	351709.808	716485.355	2.639	351721.463	716432.583	2.638	351789.568	716371.858	0.762	351916.128	716348.767	-1.26
351742.48	716573.597	1.17	351703.928	716477.316	3.007	351715.324	716430.839	3.199	351776.881	716367.654	1.163	351903.926	716344.585	-1.17
351751.969	716573.854	0.953	351698.798	716466.857	3.671	351709.933	716428.855	3.925	351766.908	716364.104	1.662	351894.679	716340.688	-1.14
351760.545	716574.173	0.698	351703.754	716467.663	3.204	351717.728	716424.502	3.163	351757.622	716360.136	1.994	351889.052	716338.109	-0.91
351769.854	716575.074	0.29	351710.692	716468.807	2.733	351725.557	716420.546	2.594	351750.903	716357.664	2.544	351875.927	716332.252	-0.36
351781.411	716574.27	-0.27	351717.434	716470.122	2.197	351734.358	716415.219	2.04	351744.25	716355.219	3.198	351863.871	716325.641	-0

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351848.317	716317.244	0.324	351962.97	716253.779	-1.67	351952.342	716203.272	-1.24	351941.113	716117.924	-0.06	351900.632	716014.774	2.064
351833.739	716309.976	0.539	351952.046	716249.734	-1.66	351963.882	716207.936	-1.45	351953.685	716122.415	-0.47	351911.274	716020.488	1.477
351819.301	716301.747	0.788	351940.521	716244.86	-1.31	351973.248	716211.928	-1.63	351963.54	716125.69	-0.88	351923.333	716027.434	0.973
351811.401	716297.151	1.08	351929.076	716241.16	-1.12	351977.426	716213.113	-1.72	351973.532	716129.595	-1.02	351935.482	716035.221	0.779
351803.309	716291.997	1.478	351916.697	716236.169	-0.69	351985.35	716187.335	-1.7	351982.681	716133.034	-1.21	351946.413	716041.657	0.593
351795.883	716287.612	1.763	351905.104	716231.401	-0.24	351973.577	716175.247	-1.35	351991.972	716136.464	-1.45	351958.71	716046.82	0.246
351787.77	716282.813	2.101	351892.627	716226.558	0.174	351954.563	716172.42	-1.01	351999.263	716138.587	-1.64	351970.309	716052.2	-0.11
351784.044	716280.475	2.405	351878.43	716220.53	0.431	351940.16	716165.825	-0.55	352003.217	716126.434	-1.59	351981.607	716058.102	-0.49
351777.343	716276.989	2.895	351864.67	716214.263	0.587	351924.354	716158.41	-0.04	352010.006	716110.429	-1.6	351992.393	716063.868	-0.87
351769.863	716273.014	3.365	351851.759	716209.355	0.693	351903.944	716150.033	0.486	351998.877	716099.28	-1.27	352002.188	716069.403	-1.1
351778.284	716270.296	3.077	351843.708	716206.1	1.104	351885.203	716140.951	0.756	351982.862	716089.963	-0.9	352013.475	716073.369	-1.32
351787.446	716268.021	2.477	351835.499	716203.055	1.574	351875.904	716136.425	0.846	351972.175	716084.369	-0.61	352019.47	716075.859	-1.48
351797.288	716264.046	2.017	351825.834	716199.537	1.84	351868.981	716133.294	1.096	351956.377	716077.716	-0.03	352023.868	716067.345	-1.45
351791.811	716253.467	2.595	351818.192	716196.381	2.177	351858.972	716129.427	1.7	351941.497	716072.377	0.367	352033.219	716054.002	-1.45
351786.577	716246.719	3.172	351811.701	716194.332	2.721	351850.727	716125.833	2.006	351925.918	716066.292	0.692	352027.545	716045.123	-1.25
351779.672	716247.525	3.8	351805.876	716191.659	3.267	351844.925	716123.612	2.414	351913.424	716061.497	0.884	352016.583	716038.855	-1.02
351783.106	716237.903	3.85	351800.866	716190.172	3.923	351838.253	716121.053	2.812	351905.159	716058.083	1.063	352007.123	716033.337	-0.8
351789.104	716240.377	3.173	351803.089	716184.014	3.833	351833.072	716118.83	3.159	351895.959	716054.132	1.437	351991.825	716026.341	-0.24
351794.072	716242.513	2.699	351809.297	716182.532	3.189	351827.203	716117.213	3.82	351886.66	716050.403	1.96	351978.219	716019.739	0.214
351803.123	716246.684	2.039	351817.045	716181.156	2.668	351824.986	716123.735	3.808	351878.115	716046.542	2.3	351963.493	716013.339	0.618
351813.902	716251.892	1.675	351828.934	716179.399	1.972	351821.895	716132.083	3.85	351870.788	716043.231	2.763	351949.809	716005.935	0.862
351823.798	716256.372	1.271	351823.755	716168.501	2.522	351829.369	716128.08	3.182	351862.548	716039.653	3.402	351939.504	716000.608	1.007
351834.228	716261.721	0.832	351817.002	716162.625	3.181	351840.323	716120.353	2.708	351859.005	716038.325	3.814	351927.78	715993.661	1.49
351846.641	716268.091	0.561	351811.783	716160.063	3.822	351854.314	716113.137	2.039	351855.126	716046.93	3.79	351918.853	715988.594	1.934
351859.541	716272.939	0.457	351813.984	716153.962	3.824	351851.019	716102.745	2.494	351848.793	716061.478	3.896	351911.853	715984.489	2.301
351872.859	716277.7	0.237	351820.037	716155.901	3.129	351844.71	716094.524	2.98	351856.605	716061.003	3.123	351905.818	715981.208	2.709
351884.325	716281.807	-0.02	351828.283	716158.472	2.498	351835.947	716093.997	3.867	351868.126	716058.609	2.497	351899.82	715977.861	3.11
351895.157	716285.327	-0.32	351836.173	716161.234	1.973	351839.274	716085.239	3.866	351879.909	716056.338	2.057	351895.298	715974.974	3.567
351906.427	716288.929	-0.76	351846.157	716164.463	1.671	351847.239	716087.188	3.006	351887.67	716045.588	1.999	351892.787	715973.398	3.869
351918.682	716293.108	-1.12	351856.633	716168.107	1.085	351856.715	716090.04	2.425	351888.837	716032.626	2.137	351886.126	715983.541	3.871
351934.151	716299.959	-1.39	351872.052	716173.616	0.724	351867.901	716093.482	1.906	351884.153	716025.156	2.517	351894.271	715984.042	3.178
351947.261	716304.44	-1.58	351886.039	716178.786	0.528	351878.693	716096.792	1.439	351877.873	716016.735	3.033	351903.375	715986.223	2.681
351958.999	716308.162	-1.73	351898.053	716183.617	0.318	351891.61	716101.296	0.887	351871.261	716013.415	3.532	351920.586	715978.369	2.085
351963.014	716289.844	-1.75	351912.382	716188.653	-0.04	351904.377	716105.685	0.662	351876.86	716003.02	3.722	351916.74	715968.638	2.586
351966.128	716271.81	-1.74	351923.497	716192.464	-0.42	351916.533	716110.112	0.428	351882.806	716006.045	3.149	351912.741	715961.504	2.989
351970.849	716258.72	-1.79	351935.683	716197.153	-0.82	351928.21	716113.338	0.22	351890.66	716009.623	2.598	351909.196	715957.493	3.435

Beach Profile Data Collection
25th September 2002

H	V	D	H	V	D	H	V	D	H	V	D
351905.729	715956.088	3.82	351982.88	715913.03	1.901	352104.6	715919.842	0.152	351860.714	716115.013	1.828
351911.505	715948.784	3.758	351984.165	715902.574	2.092	352118.76	715912.975	0.196	351852.32	716135.99	1.825
351916.924	715941.995	3.775	351983.679	715895.505	2.401	352125.855	715898.538	0.446	351845.864	716157.243	1.78
351919.925	715938.182	3.799	351982.572	715889.119	2.694	352112.417	715903.331	0.536	351838.469	716181.991	1.729
351925.23	715941.763	3.148	351983.969	715883.512	2.937	352102.494	715908.275	0.421	351831.054	716204.011	1.702
351933.39	715947.69	2.501	351988.221	715880.826	2.892	352092.22	715911.955	0.472	351822.972	716229.203	1.647
351945.693	715955.096	1.864	351995.739	715879.845	2.755	352082.563	715915.361	0.446	351817.618	716250.586	1.591
351954.994	715961.307	1.41	352000.617	715874.003	3.009	352072.326	715919.361	0.42	351809.748	716261.09	1.71
351967.291	715969.576	0.994	352003.668	715877.722	2.553	352061.978	715920.117	0.53	351795.314	716267.709	2.062
351978.901	715976.703	0.809	352010.537	715883.924	1.955	352052.852	715914.162	0.761	351787.753	716271.179	2.435
351988.834	715983.331	0.564	352016.061	715888.877	1.402	352049.065	715902.258	0.923	351778.593	716271.079	3.065
351998.035	715990.181	0.296	352022.66	715895.702	1.265	352060.233	715894.12	0.856	351771.348	716278.658	3.165
352008.7	715996.698	-0.06	352027.992	715899.038	1.192	352059.468	715882.834	1.105	351763.431	716275.809	3.657
352017.972	716002.847	-0.43	352037.226	715907.02	0.915	352057.597	715872.635	1.396			
352027.373	716009.212	-0.91	352044.18	715912.868	0.855	352055.139	715866.328	1.644			
352037.879	716014.557	-1.14	352051.703	715921.238	0.691	352054.008	715861.651	2.14			
352048.349	716020.91	-1.35	352057.726	715928.009	0.465	352053.265	715857.065	2.431			
352058.604	716007.464	-1.38	352064.347	715935.2	0.278	352051.898	715852.835	3.023			
352050.788	715996.9	-1.09	352070.171	715942.279	-0.03	352042.284	715856.3	2.998			
352040.028	715985.533	-0.59	352077.715	715950.672	-0.43	352039.335	715860.857	2.606			
352030.194	715975.141	-0.1	352083.482	715956.149	-0.7	352032.923	715866.872	2.364			
352017.891	715962.013	0.433	352089.114	715962.667	-1.02	352025.912	715862.469	2.793			
352007.862	715951.852	0.751	352092.478	715966.983	-1.1	352015.556	715866.877	2.827			
351998.6	715942.115	0.934	352098.565	715972.227	-1.29	352018.521	715872.238	2.45			
351990.582	715933.356	1.225	352106.543	715962.824	-1.21	352023.813	715877.889	1.87			
351983.335	715925.788	1.615	352109.314	715954.5	-0.98	352008.65	715907.116	1.477			
351975.575	715918.455	1.947	352115.682	715948.927	-0.91	351995.072	715921.233	1.463			
351969.817	715912.5	2.307	352128.254	715942.339	-0.84	351979.335	715938.098	1.37			
351965.264	715907.515	2.706	352126.026	715930.5	-0.41	351965.787	715954.481	1.315			
351961.09	715902.648	3.103	352117.759	715931.629	-0.36	351953.388	715968.969	1.263			
351958.356	715899.271	3.509	352108.797	715935.166	-0.36	351937.412	715989.928	1.235			
351950.612	715905.611	3.652	352097.271	715940.856	-0.37	351925.369	716009.474	1.218			
351942.253	715913.844	3.658	352090.932	715938.738	-0.27	351911.516	716031.195	1.241			
351948.707	715916.121	3.069	352079.972	715934.597	0.03	351900.169	716049.83	1.336			
351955.033	715919.572	2.638	352084.795	715930.278	0.114	351886.674	716070.006	1.534			
351964.869	715924.078	2.063	352093.612	715925.184	0.16	351874.458	716091.047	1.703			

6th November 2002

H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351765.355	716282.463		351683.715	716540.62	3.794	351870.97	716549.479	-1.25	351868.429	716503.626	-1.11	351882.354	716439.342	-1.45
351763.083	716288.696		351683.858	716548.704	3.624	351858.5	716547.546	-0.97	351883.562	716503.297	-1.18	351892.112	716440.853	-1.45
351766.364	716292.254		351688.972	716550.487	3.168	351846.366	716545.178	-0.86	351898.943	716501.087	-1.35	351901.752	716441.97	-1.46
351762.035	716303.829		351693.984	716552.435	2.757	351835.384	716543.134	-0.9	351904.446	716480.179	-1.36	351919	716442.094	-1.52
351757.225	716304.651		351694.535	716561.753	2.685	351825.915	716542.339	-0.93	351885.76	716474.87	-1.29	351932.936	716441.425	-1.64
351753.089	716316.121		351688.597	716566.733	2.924	351812.063	716539.553	-0.51	351868.568	716470.333	-1.32	351949.222	716441.617	-2.22
351749.633	716326.217		351684.762	716571.611	3.029	351801.243	716537.471	0	351857.003	716468.439	-1.2	351932.334	716432.997	-1.71
351752.596	716331.596		351681.749	716576.852	2.969	351790.81	716534.785	0.391	351848.344	716466.809	-1.07	351939.856	716414.993	-1.84
351748.158	716343.452		351677.889	716578.899	3.825	351778.035	716532.261	0.505	351833.752	716463.876	-0.44	351923.393	716409.485	-1.65
351742.375	716345.233		351680.112	716577.182	2.986	351761.872	716529.281	0.677	351820.247	716461.426	-0.06	351909.896	716406.084	-1.41
351738.347	716356.238		351682.978	716575.913	2.948	351748.393	716525.804	0.952	351804.941	716458.113	0.175	351894.348	716401.956	-1.04
351740.121	716364.826		351689.883	716575.015	2.687	351735.789	716522.724	1.317	351788.912	716454.297	0.292	351874.881	716396.535	-0.69
351734.189	716378.587		351697.289	716573.991	2.471	351723.277	716519.639	1.764	351770.121	716450.216	0.522	351859.822	716392.655	-0.38
351727.875	716382.503		351704.354	716573.451	2.276	351713.487	716517.659	2.082	351758.47	716447.235	0.74	351841.928	716387.846	-0.13
351723.642	716393.622		351714.783	716573.211	1.948	351705.325	716516.015	2.393	351749.109	716444.653	0.996	351826.222	716384.207	0.068
351718.989	716405.65		351723.867	716572.746	1.614	351698.942	716514.684	2.829	351739.134	716441.598	1.361	351807.828	716379.937	0.329
351713.977	716418.881		351733.427	716572.61	1.261	351693.451	716513.7	3.462	351728.818	716438.66	1.794	351792.761	716374.559	0.621
351709.136	716431.735		351740.99	716572.724	1.021	351700.106	716507.165	2.799	351720.228	716435.815	2.096	351779.211	716369.825	0.948
351705.709	716441.031		351748.661	716573.006	0.803	351704.338	716490.811	2.51	351712.364	716433.25	2.541	351767.261	716365.118	1.404
351702.377	716451.011		351755.38	716572.959	0.592	351702.395	716480.132	2.73	351718.531	716427.348	2.242	351757.402	716361.384	1.783
351706.499	716452.451		351764.876	716572.899	0.382	351698.842	716466.961	3.574	351723.409	716414.876	2.224	351749.247	716358.591	2.112
351703.423	716472.006		351774.373	716572.432	0.392	351699.649	716467.049	3.453	351726.925	716407.092	2.172	351742.805	716356.484	2.574
351698.864	716472.85		351783.725	716572.29	0.3	351703.319	716468.098	2.838	351723.868	716392.762	2.841	351738.887	716355.243	3.205
351695.73	716472.346		351792.146	716572.382	0.122	351711.571	716470.086	2.203	351727.833	716393.757	2.376	351744.646	716353.474	2.497
351693.229	716483.287		351803.648	716572.138	-0.25	351722.087	716473.245	1.849	351736.352	716396.24	1.985	351750.777	716345.54	2.295
351696.875	716485.886		351812.157	716571.876	-0.6	351732.074	716475.686	1.424	351746.84	716399.505	1.641	351746.783	716334.505	3.333
351701.074	716490.239	2.833	351819.981	716571.45	-0.93	351743.832	716479.364	1.035	351761.234	716404	1.011	351756.552	716324.568	2.492
351703.048	716501.546	2.575	351826.146	716571.335	-0.83	351756.567	716482.982	0.788	351775.176	716407.741	0.636	351753.726	716314.217	3.619
351697.406	716504.105	3.15	351835.561	716571.08	-0.84	351768.058	716486.892	0.59	351788.4	716411.562	0.418	351756.824	716315.217	2.92
351689.918	716505.355	3.999	351846.443	716570.742	-0.97	351779.706	716488.672	0.422	351799.555	716414.765	0.244	351762.812	716316.958	2.289
351687.269	716516.972	4.05	351857.235	716571.265	-1.16	351796.313	716492.024	0.317	351814.582	716419.494	0.059	351771.506	716319.909	1.857
351692.204	716520.219	3.436	351866.373	716571.004	-1.31	351805.674	716493.342	0.179	351827.559	716423.14	-0.07	351783.902	716324.232	1.487
351698.863	716522.769	2.712	351875.855	716569.902	-1.53	351817.907	716495.511	-0.12	351840.478	716427.618	-0.28	351797.193	716328.818	1.051
351698.505	716534.078	2.615	351886.429	716568.441	-1.7	351828.448	716498.142	-0.56	351851.123	716431.035	-0.58	351812.275	716334.359	0.628
351692.978	716536.912	3.057	351899.293	716566.31	-1.82	351842.241	716501.832	-1.01	351862.109	716434.441	-0.95	351826.154	716339.822	0.38
351688.519	716539.021	3.398	351879.968	716551.34	-1.52	351855.258	716502.91	-1.09	351872.348	716437.461	-1.29	351842.766	716346.294	0.105

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351862.593	716352.504	-0.22	351885.968	716278.07	-0.16	351818.121	716155.134	2.59	351886.726	716103.364	0.784	351889.809	716010.264	2.168
351880.097	716357.426	-0.47	351903.709	716287.176	-0.41	351828.196	716158.431	2.006	351902.393	716108.421	0.533	351903.697	716018.073	1.62
351896.464	716362.604	-0.71	351919.087	716295.157	-0.67	351838.929	716162.022	1.657	351921.133	716115.39	0.25	351915.137	716024.375	1.105
351912.241	716367.406	-0.95	351936.464	716303.259	-0.98	351852.234	716166.843	1.072	351936.008	716120.698	-0.07	351927.565	716031.198	0.75
351932.731	716372.851	-1.29	351951.812	716307.676	-1.27	351865.383	716170.803	0.684	351948.692	716124.988	-0.37	351941.577	716038.734	0.533
351939.729	716374.796	-1.43	351963.482	716312.032	-1.53	351881.372	716175.752	0.396	351960.626	716128.22	-0.72	351951.098	716044.181	0.364
351959.236	716379.945	-1.77	351980.41	716318.152	-1.83	351901.074	716182.047	0.129	351969.728	716130.085	-1.02	351961.798	716050.716	0.112
351989.686	716386.512	-2.12	351990.662	716319.837	-2.01	351915.827	716188.347	-0.11	351977.617	716132.899	-1.32	351970.92	716056.023	-0.14
351994.029	716368.448	-2.11	351989.708	716293.114	-2.01	351930.802	716194.517	-0.36	351988.569	716137.463	-1.7	351979.736	716061.641	-0.31
351994.063	716368.336	-2.12	351986.825	716280.149	-2.08	351944.739	716198.885	-0.63	351978.129	716122.071	-1.16	351987.886	716066.334	-0.7
351974.054	716359.506	-1.84	351983.683	716273.567	-2.01	351960.121	716203.873	-0.98	351973.192	716117.518	-1.62	351996.569	716070.755	-1.18
351950.714	716349.551	-1.45	351976.799	716268.368	-1.7	351974.714	716206.439	-1.41	351970.953	716118.275	-1.58	352004.808	716073.956	-1.53
351927.306	716340.191	-0.99	351962.084	716262.07	-1.33	351989.194	716209.186	-1.84	351968.535	716119.174	-1.16	352014.295	716077.327	-1.69
351908.066	716331.852	-0.71	351946.939	716255.182	-0.98	351986.971	716180.21	-1.82	351969.818	716110.054	-0.78	352023.565	716058.406	-1.58
351886.515	716322.152	-0.37	351926.018	716245.388	-0.52	351975.842	716171.339	-1.37	351996.361	716108.221	-1.74	352020.495	716050.501	-1.51
351864.147	716312.918	-0.03	351904.418	716237.639	-0.17	351961.623	716165.519	-0.89	352000.539	716099.031	-1.73	352013.526	716043.046	-1.19
351847.429	716306.05	0.223	351881.998	716229.815	0.154	351944.973	716159.34	-0.46	351993.768	716096.941	-1.43	352003.723	716036.171	-0.48
351830.634	716298.746	0.554	351862.469	716222.568	0.484	351926.074	716153.991	-0.07	351976.512	716090.897	-0.8	351993.316	716030.399	-0.02
351818.146	716293.317	0.77	351848.301	716216.659	0.743	351909.233	716149.097	0.206	351960.837	716084.318	-0.25	351983.005	716024.813	0.091
351804.227	716287.403	1.313	351835.699	716211.822	1.057	351892.716	716143.78	0.407	351947.289	716078.595	0.087	351968.061	716015.253	0.405
351792.739	716282.392	1.752	351822.376	716206.924	1.628	351877.786	716138.877	0.67	351931.148	716072.08	0.427	351950.265	716004.381	0.72
351783.576	716278.541	2.095	351811.85	716202.711	1.985	351863.254	716133.747	1.034	351914.673	716065.848	0.658	351934.461	715994.749	1.154
351776.463	716275.778	2.533	351807.486	716201.285	2.163	351852.473	716129.952	1.551	351898.478	716060.513	0.967	351922.845	715986.522	1.684
351770.129	716273.022	3.17	351803.702	716200.137	2.418	351843.72	716126.517	1.916	351886.762	716056.032	1.428	351913.377	715981.072	2.035
351773.472	716263.66	3.546	351800.14	716198.742	2.827	351834.706	716123.093	2.252	351875.402	716050.745	1.923	351905.301	715975.593	2.412
351780.296	716259.772	2.626	351798.221	716197.562	3.119	351829.165	716120.68	2.771	351867.272	716046.68	2.224	351899.761	715971.899	3.088
351784.374	716250.875	2.545	351801.359	716189.165	3.125	351826.643	716119.353	3.21	351861.059	716044.035	2.692	351897.18	715970.288	3.654
351779.976	716246.465	3.479	351806.863	716190.214	2.43	351829.664	716110.551	3.249	351857.211	716042.114	3.308	351895.804	715969.212	3.85
351783.195	716237.892	3.373	351810.365	716183.605	2.362	351835.199	716110.545	2.508	351861.2	716033.529	3.388	351901.787	715960.735	4.008
351786.746	716239.044	2.732	351805.276	716178.489	3.139	351839.577	716102.728	2.397	351866.335	716035.306	2.597	351907.683	715963.249	2.897
351792.934	716241.61	2.202	351806.834	716174.208	3.222	351834.152	716098.926	3.204	351871.551	716024.359	2.623	351915.089	715955.767	2.712
351805.065	716246.101	1.771	351807.409	716174.018	3.465	351836.949	716091.36	3.162	351867.039	716020.195	3.568	351913.418	715951.448	3.373
351818.684	716251.769	1.206	351812.518	716173.209	2.488	351839.507	716085.273	3.137	351871.695	716012.418	3.446	351911.732	715948.385	3.818
351836.414	716258.398	0.698	351816.153	716166.122	2.405	351844.797	716086.966	2.455	351877.535	716011.215	2.755	351916.245	715943.06	3.813
351851.398	716265.378	0.419	351811.69	716160.992	3.165	351858.956	716092.024	1.848	351876.956	716002.838	3.5	351920.036	715938.118	3.807
351867.386	716270.553	0.18	351814.159	716153.815	3.21	351871.235	716096.606	1.287	351880.504	716004.719	2.865	351924.04	715939.923	3.24

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H	V	D	H	V	D	H	V	D	H	V	D
351927.834	715943.411	2.564	352017.622	715871.056	2.46	352002.535	715912.513	1.198	351824.205	716147.285	2.349
351936.679	715947.922	2.128	352021.597	715864.53	2.794	351986.72	715909.274	1.696	351829.897	716150.271	2.05
351947.214	715958.754	1.594	352024.641	715867.403	2.255	351973.818	715907.134	2.083	351826.327	716162.915	2.004
351954.676	715964.951	1.266	352027.749	715875.27	1.605	351962.44	715917.476	2.153	351823.251	716176.587	1.927
351967.129	715974.857	0.88	352036.721	715879.284	1.379	351952.573	715915.958	2.503	351817.32	716192.715	1.922
351980.792	715985.793	0.592	352033.321	715889.667	1.271	351946.485	715915.257	3.057	351811.376	716210.654	1.925
351990.596	715992.894	0.431	352029.798	715901.791	0.997	351941.15	715914.823	3.71	351804.335	716211.37	2.151
352000.883	716000.094	0.231	352033.597	715912.982	0.71	351940.722	715922.793	2.978	351797.83	716212.102	2.495
352009.456	716005.852	-0.01	352042.127	715921.045	0.509	351940.613	715930.026	2.508	351793.655	716210.808	3.129
352017.126	716011.603	-0.27	352050.223	715932.89	0.126	351930.976	715926.298	3.713	351789.049	716223.191	3.225
352025.291	716016.831	-0.88	352056.946	715940.61	0.216	351933.996	715934.368	2.667	351793.926	716226.493	2.444
352033.585	716021.736	-1.45	352064.425	715948.241	0.012	351930.552	715949.563	2.248	351801.397	716231.082	2.018
352043.855	716026.316	-1.56	352071.669	715956.401	-0.35	351921.799	715959.93	2.244	351791.692	716233.585	2.432
352051.053	716018.639	-1.56	352078.73	715962.918	-0.82	351913.135	715971.981	2.236	351785.293	716232.206	3.347
352063.278	716013.706	-1.49	352087.2	715971.621	-1.15	351901.658	715983.993	2.311	351794.096	716246.692	2.105
352058.261	716007.979	-1.4	352093.875	715978.943	-1.41	351893.181	715983.726	2.901	351791.267	716257.192	2.032
352051.366	716000.28	-1.38	352098.885	715964.964	-1.2	351886.808	715982.784	3.909	351786.923	716270.457	2.05
352045.358	715993.377	-0.95	352106.064	715951.378	-0.89	351883.195	715992.477	3.543	351785.227	716284.377	1.912
352037.507	715983.035	-0.27	352109.292	715938.445	-0.68	351887.595	715996.761	2.635	351785.272	716292.402	1.879
352027.889	715971.084	0.224	352113.485	715924.064	-0.36	351892.795	716001.447	2.23	351780.853	716300.96	1.867
352014.294	715955.275	0.478	352106.725	715917.928	-0.23	351887.732	716016.172	2.123	351775.811	716311.167	1.835
352001.255	715941.675	0.815	352096.009	715915.689	-0.04	351881.864	716031.943	2.021	351771.653	716300.848	2.14
351988.776	715929.085	1.195	352081.385	715915.022	0.138	351869.032	716059.148	1.987	351770.763	716291.777	2.479
351979.574	715919.909	1.677	352072.43	715904.564	0.437	351859.121	716057.946	2.344	351767.286	716284.517	3.118
351969.869	715910.356	2.1	352069.231	715895.617	0.647	351851.562	716055.618	3.239	351759.622	716275.816	3.948
351964.195	715902.495	2.474	352061.221	715881.675	1.161	351851.521	716055.65	3.234			
351960.755	715897.576	3.13	352061.229	715872.107	1.412	351845.478	716070.105	3.197			
351972.361	715895.907	2.421	352061.312	715862.585	1.896	351850.649	716073.728	2.425			
351975.439	715888.349	3.015	352059.716	715857.231	2.296	351856.912	716077.903	2.084			
351986.272	715888.546	2.317	352058.293	715851.957	3.187	351850.602	716091.728	2.1			
351988.477	715880.978	2.964	352047.377	715854.337	3.155	351846.737	716103.041	2.099			
351997.26	715880.849	2.754	352039.906	715857.737	3.11	351842.106	716112.969	2.132			
352000.815	715873.688	3.269	352040.538	715862.487	2.404	351836.312	716127.593	2.128			
352004.715	715876.632	2.634	352047.234	715868.153	1.688	351828.147	716131.793	2.456			
352007.251	715879.704	2.166	352040.099	715876.742	1.369	351822.116	716132.025	3.203			
352011.64	715868.862	3.061	352022.023	715908.295	0.984	351817.426	716144.864	3.215			

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H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351702.5	716461.707	1.609	351818.976	716538.434	-2.08	351825.38	716492.163	-1.77	351782.978	716410.584	-0.96	351750.003	716325.064	1.386
351698.047	716468.775	2.11	351810.337	716536.905	-1.72	351833.621	716494.723	-1.99	351791.941	716413.858	-1.06	351754.629	716325.793	0.831
351695.137	716479.61	2.281	351800.727	716534.931	-1.38	351842.551	716497.903	-2.28	351803.663	716417.944	-1.18	351753.883	716313.543	1.643
351692.491	716490.879	2.36	351790.355	716533.046	-1.02	351848.86	716500.108	-2.53	351813.691	716421.259	-1.29	351758.533	716315.126	0.962
351691.302	716500.963	2.362	351780.931	716530.821	-0.88	351854.294	716501.933	-2.75	351825.041	716425.313	-1.45	351765.554	716317.909	0.332
351689.634	716514.173	2.293	351770.698	716528.745	-0.87	351865.789	716484.961	-2.73	351838.861	716430.584	-1.69	351773.685	716321.357	-0.07
351687.65	716526.498	2.187	351762.268	716527.53	-0.81	351857.08	716480.983	-2.44	351851.033	716434.588	-1.88	351784.118	716325.772	-0.38
351685.445	716539.143	2.146	351753.044	716525.949	-0.53	351846.371	716478.413	-2.12	351861.563	716437.444	-2.07	351794.032	716329.849	-0.65
351685.152	716552.928	1.859	351741.922	716524.256	-0.29	351834.46	716474.894	-1.81	351873.948	716441.754	-2.35	351804.016	716334.031	-1.02
351686.46	716562.597	1.557	351729.311	716522.531	-0.1	351820.307	716470.549	-1.53	351885.719	716446.179	-2.69	351813.987	716338.726	-1.38
351680.206	716576.446	1.496	351718.683	716520.957	0.191	351808.491	716466.515	-1.33	351896.249	716430.405	-2.68	351823.29	716342.791	-1.47
351678.004	716578.714	2.262	351711.065	716519.582	0.531	351795.981	716462.667	-1.14	351890.709	716426.085	-2.47	351832.007	716347.568	-1.6
351681.347	716576.513	1.446	351704.016	716518.28	0.937	351782.781	716457.936	-1.07	351878.853	716420.413	-2.15	351832.037	716347.603	-1.6
351686.096	716576.204	1.244	351697.736	716517.342	1.41	351769.398	716451.197	-1.04	351867.688	716414.2	-1.99	351841.644	716351.589	-1.58
351693.323	716575.593	0.921	351692.531	716515.941	1.943	351761.652	716448.515	-0.95	351857.192	716408.311	-1.84	351852.093	716357.003	-1.67
351702.018	716575.173	0.554	351695.933	716507.919	1.694	351752.633	716442.677	-0.63	351842.592	716401.255	-1.64	351864.011	716363.672	-1.78
351711.932	716574.851	0.254	351703.862	716502.472	1.046	351741.746	716438.827	-0.34	351830.293	716395.186	-1.45	351875.015	716368.87	-1.9
351721.538	716574.499	-0	351710.9	716496.392	0.59	351731.106	716435.863	-0.01	351818.244	716389.76	-1.33	351886.145	716374.238	-2.05
351730.403	716574.228	-0.25	351706.443	716488.928	0.933	351724.382	716434.44	0.289	351803.575	716383.516	-1.2	351897.177	716380.005	-2.21
351740.343	716574.228	-0.48	351702.226	716481.879	1.339	351718.024	716432.892	0.727	351790.839	716377.246	-0.96	351909.292	716385.804	-2.4
351749.731	716573.96	-0.7	351698.747	716476.814	1.782	351712.937	716431.616	1.21	351779.848	716372.691	-0.64	351919.762	716390.414	-2.59
351759.132	716573.631	-0.96	351695.344	716473.049	2.413	351709.114	716431.21	1.673	351770.145	716368.958	-0.44	351941.833	716363.597	-2.8
351768.743	716573.338	-1.1	351699.01	716466.891	1.934	351705.041	716442.094	2.007	351760.246	716365.627	-0.22	351931.648	716358.502	-2.58
351776.607	716572.873	-1.03	351704.038	716467.455	1.32	351711.751	716438.435	1.14	351751.674	716362.071	0.14	351916.731	716352.629	-2.37
351785.131	716572.122	-1.04	351710.77	716468.744	0.71	351724.721	716422.856	0.494	351745.562	716360.161	0.539	351903.181	716345.2	-2.15
351793.891	716571.296	-1.27	351718.581	716469.984	0.223	351724.764	716422.787	0.477	351740.94	716358.575	1.035	351889.073	716338.487	-1.92
351802.915	716570.486	-1.59	351730.155	716471.967	-0.15	351721.189	716418.573	0.846	351738.008	716357.548	1.349	351874.123	716331.097	-1.7
351811.399	716569.702	-1.88	351739.507	716473.638	-0.38	351718.061	716414.134	1.223	351732.749	716369.943	1.372	351858.228	716322.917	-1.51
351819.906	716569.264	-2.21	351750.242	716475.531	-0.86	351716.911	716410.585	1.459	351738.196	716371.643	0.826	351844.206	716315.856	-1.33
351827.783	716569.242	-2.53	351760.192	716477.797	-1.02	351720.371	716401.82	1.374	351744.063	716374.03	0.351	351831.68	716309.176	-1.06
351835.797	716568.484	-2.63	351770.898	716480.61	-1.11	351723.751	716392.695	1.358	351758.552	716349.976	0.022	351821.133	716303.132	-0.82
351844.11	716567.406	-2.69	351777.085	716481.972	-1.25	351728.387	716393.968	0.952	351753.704	716346.534	0.309	351807.464	716296.092	-0.5
351847.033	716567.602	-2.71	351787.716	716484.491	-1.31	351735.496	716395.827	0.409	351749.551	716343.833	0.669	351795.475	716289.685	-0.18
351839.043	716546.753	-2.79	351796.831	716485.968	-1.43	351746.317	716399.069	-0.11	351746.271	716341.937	1.099	351785.986	716284.674	0.153
351833.955	716543.857	-2.57	351805.901	716487.519	-1.55	351758.116	716402.531	-0.45	351743.945	716341.59	1.353	351777.139	716279.731	0.733
351827.2	716540.903	-2.51	351815.704	716489.609	-1.62	351771	716406.782	-0.71	351747.229	716333.211	1.329	351772.188	716277.033	1.165

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H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351768.159	716274.102	1.613	351811.826	716206.287	0.177	351848.843	716128.358	-0.29	351859.576	716037.855	1.408	351901.525	715980.488	0.746
351771.939	716267.642	1.788	351819.3	716185.001	0.103	351839.575	716123.61	0.073	351853.256	716051.999	1.549	351896.944	715976.995	1.338
351774.782	716260.69	1.702	351821.635	716175.656	0.132	351834.181	716120.942	0.411	351855.163	716052.938	1.103	351893.907	715974.881	1.93
351779.994	716259.972	1.145	351808.506	716169.703	1.375	351827.115	716117.843	1.133	351861.472	716054.946	0.507	351892.385	715973.691	2.439
351787.675	716257.507	0.61	351810.841	716163.184	1.315	351831.359	716107.308	1.091	351876.872	716035.318	0.242	351888.113	715980.746	2.398
351781.144	716244.232	1.621	351813.912	716154.365	1.365	351838.42	716106.075	0.493	351873.694	716029.718	0.574	351893.637	715983.994	1.113
351783.409	716237.736	1.559	351817.628	716144.31	1.371	351835.625	716095.677	1.129	351869.913	716024.486	1.101	351914.734	715970.639	0.399
351789.501	716239.412	0.949	351822.99	716144.848	0.746	351839.511	716085.208	1.195	351866.966	716021.209	1.654	351911.577	715963.238	0.922
351798.217	716242.316	0.286	351823.108	716144.944	0.742	351845.027	716086.827	0.587	351870.942	716014.43	1.57	351908.21	715958.671	1.608
351811.306	716247.336	-0.25	351831.034	716148.125	0.105	351854.471	716090.805	0.023	351877.15	716002.952	1.677	351905.222	715956.371	2.409
351826.51	716252.677	-0.57	351836.289	716139.017	0.027	351866.094	716095.61	-0.39	351880.391	716004.58	1.188	351910.538	715949.549	2.319
351841.268	716257.729	-0.86	351829.923	716132.29	0.5	351878.197	716100.572	-0.63	351888.666	716009.445	0.379	351917.197	715941.624	2.32
351855.89	716263.954	-1.21	351824.83	716126.869	0.831	351891.031	716105.769	-1	351897.973	716015.178	-0.1	351920.439	715937.695	2.273
351874.014	716270.684	-1.53	351832.628	716140.262	0.185	351901.695	716110.756	-1.28	351908.266	716021.996	-0.42	351924.227	715941.145	1.373
351890.952	716277.483	-1.71	351834.807	716161.205	-0.17	351914.011	716116.04	-1.53	351919.247	716028.614	-0.69	351929.996	715946.196	0.675
351904.61	716281.542	-1.83	351848.077	716167.088	-0.47	351924.527	716121.055	-1.64	351929.421	716034.555	-0.94	351939.345	715953.568	0.017
351919.728	716287.565	-2.07	351860.45	716172.957	-0.75	351935.972	716125.815	-1.78	351940.406	716040.846	-1.23	351950.418	715962.214	-0.37
351932.321	716292.084	-2.31	351872.531	716178.406	-1.1	351944.942	716130.197	-1.98	351951.513	716047.928	-1.44	351960.234	715969.208	-0.58
351942.554	716295.17	-2.5	351884.919	716183.187	-1.37	351953.801	716133.173	-2.04	351961.96	716053.774	-1.64	351972.83	715977.761	-0.88
351952.861	716297.744	-2.7	351897.831	716188.26	-1.56	351963.942	716136.483	-2.24	351969.818	716058.231	-1.75	351984.384	715986.665	-1.2
351956.184	716262.126	-2.68	351907.865	716192.004	-1.65	351980.756	716142.187	-2.63	351979.864	716063.437	-1.91	351994.31	715994.928	-1.44
351945.412	716255.457	-2.43	351919.942	716196.438	-1.88	351988.449	716126.441	-2.69	351988.963	716067.972	-2.1	352005.411	716004.202	-1.7
351931.466	716247.123	-2.16	351932.65	716201.597	-2.02	351991.482	716111.236	-2.59	352008.351	716076.282	-2.57	352017.681	716012.584	-1.94
351918.835	716240.515	-1.92	351943.906	716205.658	-2.24	351981.025	716102.967	-2.29	352031.755	716058.215	-2.82	352027.5	716018.245	-2.16
351904.942	716232.976	-1.73	351956.672	716209.506	-2.44	351977.911	716100.985	-2.25	352031.838	716058.242	-2.82	352057.551	716014.418	-2.66
351892.891	716225.664	-1.58	351964.285	716211.53	-2.6	351965.075	716091.517	-1.96	352023.15	716051.255	-2.52	352053.691	716007.578	-2.45
351880.522	716219.618	-1.4	351974.097	716191.767	-2.72	351953.9	716083.006	-1.72	352008.8	716043.138	-2.14	352045.402	715996.777	-2.09
351864.501	716214.3	-1.1	351963.773	716185.425	-2.44	351944.854	716075.603	-1.55	351996.607	716036.235	-1.88	352037.659	715987.104	-1.85
351853.074	716209.715	-0.86	351951.847	716178.796	-2.23	351934.939	716069.728	-1.39	351983.008	716028.722	-1.64	352029.454	715977.571	-1.66
351839.946	716205.029	-0.56	351938.367	716172.005	-1.99	351923.677	716063.63	-1.16	351968.663	716021.267	-1.4	352019.963	715966.972	-1.43
351826.536	716200.097	-0.25	351924.712	716164.697	-1.81	351910.548	716058.015	-0.84	351951.767	716012.315	-1.07	352010.931	715956.181	-1.19
351817.937	716196.764	0.024	351910.268	716157.863	-1.65	351895.665	716052.039	-0.47	351940.02	716006.202	-0.77	352002.891	715946.921	-0.95
351809.782	716192.937	0.525	351897.884	716151.502	-1.51	351883.789	716047.581	-0.22	351927.564	715998.833	-0.51	351997.254	715939.342	-0.72
351801.325	716189.429	1.247	351883.696	716144.848	-1.2	351875.392	716043.927	0.094	351918.68	715992.659	-0.24	351990.643	715930.844	-0.52
351797.048	716201.456	1.345	351872.096	716139.096	-0.85	351868.6	716041.459	0.483	351917.788	715992.095	-0.21	351984.087	715922.656	-0.24
351802.013	716203.996	0.849	351859.48	716133.367	-0.54	351863.867	716039.514	0.915	351908.154	715984.989	0.219	351978.444	715915.476	-0.08

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H	D	V	H	D	V
351973.548	715908.261	0.219	352056.683	715869.584	-0.05
351970.547	715903.847	0.487	352055.345	715863.605	0.268
351967.706	715899.01	0.873	352053.491	715858.417	0.944
351964.914	715894.692	1.36	352051.61	715852.953	1.664
351978.434	715891.484	0.806	352049.355	715862.436	0.525
351979.732	715885.551	1.576	352024.862	715907.202	-0.78
351989.152	715880.033	1.575	352014.117	715912.186	-0.58
351995.799	715882.633	0.957	352002.169	715916.082	-0.47
352000.77	715873.662	1.791	351987.627	715918.555	-0.26
352005.376	715876.065	1.047	351971.129	715922.46	0.012
352014.314	715873.828	0.696	351957.292	715926.342	0.266
352014.924	715867.329	1.467	351947.132	715933.797	0.398
352025.949	715862.445	1.118	351940.674	715929.795	0.891
352027.853	715861.781	0.962	351936.567	715926.671	1.339
352031.653	715871.962	0.119	351933.486	715923.704	1.786
352037.639	715878.575	-0.18			
352034.942	715890.491	-0.56			
352029.297	715904.702	-0.86			
352036.014	715916.571	-0.96			
352046.534	715923.167	-1.39			
352052.103	715930.965	-1.49			
352056.771	715940.036	-1.61			
352066.323	715946.562	-1.77			
352071.728	715950.037	-1.79			
352078.569	715955.956	-1.93			
352085.346	715961.709	-2.21			
352093.593	715968.097	-2.5			
352108.59	715956.398	-2.55			
352108.24	715949.312	-2.39			
352103.204	715938.579	-2.04			
352098.263	715927.823	-1.9			
352087.035	715915.14	-1.66			
352074.468	715912.066	-1.35			
352073.923	715901.407	-0.97			
352067.425	715890.482	-0.66			
352062.831	715878.305	-0.37			

H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351765.449	716287.825	2.769	351703.091	716574.953	2.345	351721.168	716521.593	1.838	351879.891	716489.837	-1.13	351812.113	716419.949	-0.03
351762.425	716295.852	2.761	351710.674	716574.612	2.088	351712.102	716521.18	1.981	351874.041	716486.253	-0.97	351820.639	716421.789	-0.06
351757.737	716305.401	2.77	351718.339	716573.949	1.884	351703.745	716520.854	2.377	351864.138	716482.289	-0.75	351827.019	716423.1	-0.04
351753.322	716316.498	2.757	351726.82	716573.564	1.709	351697.192	716520.334	2.951	351854.598	716479.395	-0.53	351836.803	716426.272	0
351749.748	716326.521	2.709	351735.241	716573.252	1.557	351692.204	716520.092	3.523	351843.806	716476.056	-0.28	351847.349	716429.887	-0.07
351746.347	716336.384	2.649	351743.77	716572.711	1.316	351688.655	716519.742	3.914	351833.462	716472.916	-0.08	351859.155	716433.758	-0.25
351742.936	716344.374	2.69	351753.11	716572.059	0.977	351695.255	716515.436	3.169	351822.502	716469.358	0.128	351870.233	716437.618	-0.46
351739.349	716354.34	2.685	351762.259	716570.941	0.702	351702.189	716508.845	2.509	351811.514	716466.559	0.301	351879.745	716441.801	-0.68
351736.466	716361.747	2.702	351771.22	716569.796	0.333	351709.509	716501.35	2.016	351801.242	716463.488	0.384	351889.02	716446.066	-0.89
351732.946	716369.878	2.708	351779.238	716568.586	0.036	351711.08	716490.267	1.978	351791.999	716460.984	0.433	351899.323	716449.85	-1.14
351729.15	716379.567	2.802	351787.428	716567.268	-0.32	351707.319	716483.768	2.308	351782.632	716457.989	0.418	351914.039	716426.743	-1.18
351725.606	716388.372	2.851	351792.923	716564.514	-0.44	351703.64	716477.595	2.743	351772.714	716455.215	0.363	351903.326	716420.805	-0.88
351722.481	716396.609	2.912	351801.115	716564.503	-0.47	351701.174	716472.969	3.153	351765.856	716452.816	0.469	351893.843	716416.226	-0.69
351718.86	716405.707	3.044	351805.055	716564.677	-0.22	351698.899	716466.99	3.47	351759.551	716450.662	0.844	351883.751	716412.154	-0.48
351716.046	716413.351	3.131	351815.002	716564.814	-0.2	351701.813	716467.57	3.175	351750.984	716447.73	1.264	351872.392	716407.983	-0.3
351712.387	716423.35	3.2	351825.175	716565.044	-0.41	351707.693	716468.613	2.565	351744.814	716445.502	1.51	351861.725	716403.784	-0.25
351709.184	716432.04	3.317	351834.446	716565.275	-0.6	351714.885	716470.62	2.063	351737.133	716443.248	1.742	351850.757	716399.095	-0.11
351704.957	716443.009	3.545	351844.308	716565.933	-0.78	351723.467	716473.18	1.86	351728.789	716440.757	1.849	351838.193	716394.185	0.005
351701.912	716453.048	3.532	351853.952	716566.255	-1.01	351731.82	716475.966	1.666	351721.561	716438.637	1.98	351826.732	716389.977	0.084
351700.317	716463.703	3.484	351865.865	716566.302	-1.06	351740.675	716478.409	1.408	351716.233	716437.225	2.375	351814.88	716385.802	0.23
351697.827	716469.943	3.795	351859.66	716544.956	-1.08	351747.585	716480.298	1.045	351710.103	716435.244	3.064	351801.728	716379.976	0.392
351694.175	716480.027	4.037	351852.949	716542.646	-1	351753.279	716481.323	0.512	351717.81	716431.657	2.351	351790.146	716376.196	0.644
351691.802	716491.71	4.073	351844.347	716541.448	-0.82	351760.196	716481.681	0.161	351725.355	716427.863	1.881	351778.864	716372.059	1.195
351690.692	716501.88	4.051	351836.749	716540.321	-0.65	351768.666	716480.079	0.106	351730.017	716417.688	1.813	351769.576	716368.838	1.543
351688.008	716513.677	4.205	351827.474	716539.93	-0.43	351775.766	716483.204	0.166	351727.127	716408.975	2.059	351769.558	716368.891	1.535
351686.749	716523.998	4.022	351819.254	716538.633	-0.22	351780.886	716483.727	0.289	351724.491	716400.946	2.544	351762.792	716366.864	1.606
351684.524	716536.424	4.052	351809.35	716536.678	-0.05	351789.83	716485.94	0.378	351723.95	716393.504	2.852	351755.839	716364.629	1.681
351682.288	716548.082	4.003	351800.063	716534.158	0.092	351800.292	716488.135	0.3	351727.603	716394.543	2.442	351748.757	716362.084	1.828
351682.352	716558.316	3.714	351790.884	716532.208	0.102	351809.537	716490.73	0.185	351735.101	716397.414	1.876	351743.761	716360.251	2.077
351685.67	716567.169	3.257	351783.611	716530.474	-0.11	351819.687	716493.773	0.015	351745.476	716401.068	1.697	351739.177	716358.759	2.529
351679.72	716575.213	3.239	351773.938	716528.128	-0.14	351829.32	716496.922	-0.18	351755.62	716404.897	1.515	351747.566	716354.864	1.964
351677.953	716579.086	3.86	351766.776	716526.995	0.044	351837.373	716499.692	-0.35	351764.151	716407.595	1.235	351755.676	716350.469	1.763
351679.553	716577.156	3.118	351757.993	716525.414	0.398	351845.111	716502.589	-0.55	351773.833	716410.157	0.816	351762.83	716344.051	1.639
351683.937	716576.244	2.999	351749.621	716524.069	0.836	351854.088	716505.547	-0.73	351784.272	716413.037	0.481	351762.418	716334.265	1.757
351689.089	716575.774	2.797	351740.686	716523.26	1.22	351863.294	716507.57	-0.96	351793.566	716415.24	0.233	351759.002	716326.252	1.971
351695.585	716575.285	2.601	351730.866	716522.402	1.618	351871.476	716508.582	-1.19	351803.788	716418.033	0.118	351756.372	716319.502	2.342

H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351755.413	716311.473	2.736	351777.509	716273.037	2.338	351833.899	716214.001	1.306	351965.904	716185.723	-1.04	351975.874	716133.499	-0.88
351759.491	716312.552	2.349	351770.823	716270.547	3.01	351823.335	716208.802	1.558	351955.987	716179.596	-0.81	351987.531	716137.994	-1.15
351767.682	716315.832	1.861	351773.824	716262.949	3.075	351815.1	716204.928	1.761	351947.367	716174.02	-0.62	351992.157	716127.28	-1.16
351775.886	716318.713	1.603	351776.492	716256.235	3.066	351805.716	716201.516	2.148	351939.384	716169.666	-0.44	352003.984	716116.428	-1.37
351786.102	716322.663	1.415	351779.979	716247.051	3.053	351801.45	716199.856	2.516	351928.801	716163.543	-0.2	351997.353	716106.433	-1.09
351796.447	716326.066	1.259	351782.161	716241.618	2.991	351798.063	716198.357	2.923	351919.208	716158.634	-0.02	351987.364	716100.644	-0.83
351806.912	716329.998	0.846	351783.352	716237.965	2.945	351800.911	716191.294	2.806	351907.61	716152.182	0.248	351976.75	716094.706	-0.59
351816.973	716334.154	0.496	351786.792	716239.521	2.583	351803.811	716183.351	2.786	351897.613	716147.426	0.354	351962.384	716086.723	-0.28
351825.902	716337.858	0.397	351795.649	716242.745	1.913	351806.709	716175.48	2.717	351890.065	716143.771	0.201	351949.071	716082.427	-0.09
351834.904	716341.507	0.311	351806.079	716247.507	1.61	351811.632	716172.04	2.33	351882.811	716139.519	0.285	351937.83	716077.665	0.066
351843.385	716345.055	0.266	351816.967	716252.656	1.435	351810.614	716166.598	2.599	351882.713	716139.472	0.295	351923.658	716072.61	0.265
351853.407	716349.109	0.181	351826.783	716257.138	1.169	351821.993	716162.913	1.903	351876.236	716136.195	0.43	351911.4	716068.097	0.513
351863.547	716353.513	0.058	351835.666	716261.511	0.682	351817.864	716160.356	1.966	351869.868	716133.023	0.609	351903.045	716065.586	0.806
351874.578	716358.067	-0.1	351843.647	716265.223	0.617	351812.958	716158.327	2.783	351862.868	716129.083	0.996	351891.529	716061.583	1.208
351883.112	716362.486	-0.25	351853.532	716269.463	0.64	351815.359	716151.312	2.695	351853.421	716124.408	1.49	351881.845	716058.263	1.346
351892.322	716367.329	-0.41	351863.34	716273.571	0.528	351818.217	716143.617	2.719	351845.858	716120.952	1.723	351872.335	716054.862	1.533
351902.576	716372.985	-0.55	351872.945	716277.308	0.344	351824.146	716137.836	2.001	351839.065	716117.287	1.913	351864.91	716052.079	1.703
351913.367	716378.047	-0.74	351883.239	716281.758	0.17	351829.756	716138.524	1.914	351834.067	716114.807	1.877	351860.831	716050.459	1.963
351923.815	716382.179	-0.97	351895.138	716287.224	-0.06	351839.054	716142.041	1.715	351829.234	716112.809	2.76	351857.099	716048.88	2.746
351932.265	716385.471	-1.16	351908.749	716292.56	-0.36	351847.109	716145.733	1.408	351831.976	716104.942	2.778	351854.901	716047.931	3.337
351943.43	716365.671	-1.27	351921.098	716297.439	-0.62	351853.91	716148.86	0.995	351834.696	716097.678	2.742	351858.826	716039.345	3.354
351932.224	716357.551	-0.96	351934.632	716301.783	-0.89	351862.452	716153.328	0.524	351838.243	716088.313	2.908	351862.02	716032.218	3.353
351920.801	716351.821	-0.74	351945.034	716304.491	-1.1	351869.804	716156.135	0.269	351841.824	716088.221	2.144	351871.046	716029.295	2.136
351910.273	716346.361	-0.55	351952.391	716306.832	-1.33	351876.152	716159.459	0.207	351846.366	716088.542	1.657	351869.165	716022.278	2.881
351897.565	716339.668	-0.33	351948.982	716277.284	-1.27	351881.6	716162.418	0.333	351853.469	716091.719	1.758	351869.968	716016.404	3.208
351886.219	716333.883	-0.11	351948.463	716268.946	-1.29	351888.513	716166.027	0.413	351864.343	716095.94	1.463	351873.417	716009.834	3.316
351875.054	716327.583	0.106	351940.822	716260.315	-1.07	351896.372	716170.99	0.308	351875.634	716100.964	1.041	351876.97	716003.236	3.361
351862.641	716320.029	0.301	351928.412	716253.704	-0.73	351904.451	716176.177	0.159	351888.093	716104.64	0.431	351881.507	716005.845	2.502
351851.516	716313.802	0.461	351917.686	716248.515	-0.48	351913.082	716181.698	-0.06	351897.265	716108.587	0.227	351890.513	716011.383	1.73
351839.936	716307.102	0.508	351905.885	716243.074	-0.21	351922.961	716187.947	-0.27	351906.135	716111.879	0.084	351901.111	716018.958	1.4
351830.146	716301.65	0.552	351893.682	716238.648	0.062	351930.612	716192.972	-0.45	351912.395	716114.243	0.139	351912.778	716026.542	1.076
351821.462	716296.582	0.831	351881.341	716234.021	0.33	351939.542	716198.785	-0.66	351924.309	716117.99	0.023	351922.151	716032.183	0.744
351813.295	716292.39	1.23	351871.292	716230.046	0.548	351947.313	716203.014	-0.83	351935.915	716121.243	-0.13	351935.109	716039.679	0.447
351802.517	716286.325	1.464	351860.579	716225.86	0.633	351955.434	716207.515	-1.05	351950.848	716125.343	-0.35	351947.061	716047.233	0.226
351792.057	716280.489	1.687	351850.935	716221.821	0.654	351962.431	716211.243	-1.26	351963.87	716129.146	-0.59	351958.764	716054.31	0.004
351784.278	716276.326	1.96	351841.977	716217.896	0.844	351976	716192.226	-1.31	351965.083	716129.704	-0.6	351969.325	716059.281	-0.21

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H	D	V	H	D	V	H	D	V	H	D	V	H	D	V
351983.416	716068.166	-0.49	352040.566	716035.141	-1.28	352032.267	715899.66	0.761	352018.672	715907.021	1.004	351784.924	716255.776	2.271
351997.097	716075.722	-0.78	352047.54	716023.24	-1.22	352021.732	715903.697	0.99	352008.353	715912.198	1.124	351781.112	716264.672	2.301
352007.282	716081.61	-1.04	352056.553	716017.551	-1.33	352026.968	715911.967	0.486	351998.142	715909.07	1.26	351776.797	716273.83	2.355
352016.89	716086.278	-1.35	352051.085	716006.462	-0.94	352032.602	715921.412	0.37	351985.065	715908.542	1.543			
352025.462	716070.751	-1.36	352044.836	715999.619	-0.7	352035.773	715927.494	0.216	351972.659	715911.441	1.769			
352018.017	716061.093	-1.04	352037.595	715990.208	-0.45	352041.537	715933.349	0.211	351963.275	715915.239	1.915			
352006.839	716052.582	-0.75	352030.11	715980.351	-0.21	352042.591	715939.536	0.244	351952.44	715920.648	2.085			
351996.413	716044.423	-0.49	352022.782	715972.354	-0.02	352048.997	715946.647	0.082	351941.935	715927.275	2.28			
351984.058	716036.57	-0.23	352014.873	715963.801	0.2	352056.162	715954.591	-0.1	351932.653	715939.329	2.26			
351974.083	716026.901	0.027	352007.952	715955.462	0.402	352063.423	715962.682	-0.35	351920.901	715951.509	2.384			
351960.469	716016.088	0.354	352000.993	715947.182	0.637	352071.291	715971.726	-0.65	351911.191	715961.684	2.488			
351950.576	716009.789	0.536	351992.856	715938.96	0.907	352079.354	715979.784	-0.94	351903.075	715974.44	2.429			
351941.194	716004.98	0.774	351985.004	715930.603	1.18	352094.391	715993.046	-1.44	351894.188	715986.532	2.521			
351929.437	715998.588	1.135	351978.47	715922.983	1.457	352095.749	715972.529	-1.13	351889.029	715995.75	2.379			
351919.133	715992.397	1.433	351973.4	715917.168	1.674	352105.578	715966.121	-1.17	351882.955	716007.019	2.29			
351910.107	715986.848	1.745	351967.716	715909.911	1.92	352105.557	715966.093	-1.18	351877.599	716017.423	2.187			
351902.686	715981.55	2.147	351964.967	715904.911	2.092	352110.162	715957.728	-1.01	351870.189	716029.651	2.196			
351897.202	715976.589	2.833	351962.116	715900.671	2.458	352107.464	715951.353	-0.85	351864.446	716042.588	2.042			
351893.291	715973.835	3.436	351960.459	715897.93	3.034	352103.197	715943.388	-0.53	351860.754	716053.847	1.716			
351899.522	715965.208	3.418	351967.933	715895.598	2.521	352099.95	715934.748	-0.29	351857.009	716064.543	1.65			
351905.869	715956.853	3.433	351970.355	715891.66	2.843	352097.932	715928.113	-0.16	351850.758	716077.572	1.699			
351912.395	715948.981	3.248	351976.525	715888.138	2.923	352093.488	715919.119	-0.09	351846.747	716090.554	1.673			
351920.101	715939.378	3.246	351984.293	715883.292	3.011	352086.347	715913.644	0.045	351840.377	716103.434	1.762			
351925.214	715934.677	3.07	351991.499	715882.318	2.746	352082.802	715903.402	0.548	351834.458	716116.482	1.853			
351930.346	715938.218	2.439	351997.736	715875.44	3.246	352081.027	715893.927	0.873	351830.082	716128.67	1.934			
351936.831	715944.109	1.915	352000.745	715874.158	3.243	352077.123	715886.009	1.008	351825.537	716142.044	1.94			
351946.36	715953.221	1.516	352004.032	715878.817	2.462	352076.867	715876.836	1.45	351820.704	716155.537	1.944			
351958.002	715964.021	1.104	352011.542	715874.848	2.436	352071.57	715868.067	1.581	351820.394	716169.252	1.87			
351966.549	715972.239	0.802	352010.723	715869.241	3.13	352065.952	715864.341	1.799	351816.355	716180.004	1.932			
351976.356	715982.052	0.494	352017.053	715866.227	3.231	352061.441	715856.596	2.557	351809.645	716190.099	2.109			
351984.712	715990.273	0.283	352025.301	715862.691	2.907	352058.735	715851.864	3.273	351805.974	716199.523	2.187			
351993.684	715998.047	0.072	352028.062	715867.189	2.388	352050.024	715853.548	3.238	351802.513	716208.96	2.2			
352001.815	716005.528	-0.12	352029.571	715870.184	1.874	352041.121	715856.52	3.177	351798.106	716219.43	2.258			
352010.836	716013.821	-0.38	352031.905	715875.671	1.617	352041.87	715863.318	2.401	351794.951	716227.606	2.258			
352019.9	716021.303	-0.63	352036.292	715880.082	1.44	352041.152	715872.09	1.718	351790.678	716236.966	2.328			
352031.216	716029.245	-0.93	352035.18	715889.913	0.997	352027.177	715894.746	1.116	351787.724	716246.04	2.304			

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351765.275	716282.647	3.074	351744.008	716574.415	0.842	351757.336	716541.006	0.224	351878.549	716503.674	-1.42	351848.239	716437.312	-0.31
351761.029	716294.217	3.261	351754.613	716574.492	0.512	351749.328	716541.469	0.41	351883.359	716503.414	-1.64	351858.691	716440.926	-0.57
351756.012	716308.094	3.238	351765.177	716574.764	0.139	351741.028	716541.571	0.769	351878.907	716482.767	-1.49	351870.341	716444.77	-0.88
351752.025	716319.405	3.22	351774.827	716574.709	-0.12	351759.78	716529.536	-0.05	351882.945	716469.34	-1.69	351880.469	716448.511	-1.21
351748.438	716329.642	3.229	351781.202	716574.072	-0.36	351754.151	716521.681	0.066	351872.564	716467.354	-1.1	351886.142	716450.751	-1.42
351743.588	716342.071	3.278	351791.567	716572.29	-0.43	351746.188	716520.139	0.391	351858.823	716466.054	-0.78	351906.222	716430.842	-1.59
351739.578	716352.642	3.265	351794.309	716572.108	-0.12	351737.486	716519.307	0.971	351844.825	716462.411	-0.41	351898.582	716426.88	-1.32
351735.264	716363.762	3.255	351805.34	716573.09	-0.1	351726.655	716518.581	1.452	351829.333	716459.123	-0.05	351885.471	716421.581	-0.93
351730.298	716375.857	3.333	351818.594	716573.875	-0.35	351716.874	716517.953	1.8	351816.02	716456.277	0.224	351870.865	716415.454	-0.54
351725.779	716387.299	3.428	351831.371	716574.728	-0.58	351707.823	716517.523	2.338	351799.623	716453.263	0.413	351856.31	716408.439	-0.18
351721.002	716399.405	3.489	351844.78	716575.222	-0.86	351699.578	716517.2	2.732	351783.192	716449.819	0.523	351845.654	716403.252	0.072
351715.837	716413.092	3.472	351855.857	716575.637	-1.08	351692.926	716516.52	3.394	351770.962	716447.504	0.6	351834.865	716398.155	0.302
351710.756	716426.804	3.487	351867.98	716575.81	-1.29	351688.862	716516.276	3.913	351759.367	716445.39	0.58	351823.433	716392.497	0.285
351706.287	716438.779	3.429	351880.474	716576.008	-1.27	351694.558	716511.063	3.226	351749.824	716443.662	0.699	351816.094	716388.543	0.161
351701.421	716453.112	3.548	351890.92	716575.705	-1.33	351702.06	716503.895	2.644	351739.943	716441.755	1.342	351803.094	716381.75	0.357
351700.021	716464.813	3.439	351907.259	716576.091	-1.46	351711.314	716498.602	2.284	351731.441	716440.372	2.047	351791.136	716375.243	0.46
351698.608	716468.566	3.592	351898.59	716569.919	-1.44	351708.871	716487.608	2.49	351724.472	716439.075	2.57	351782.808	716371.204	0.577
351696.014	716471.965	3.963	351887.758	716565.113	-1.49	351703.591	716481.38	2.847	351715.353	716436.763	2.821	351776.623	716368.312	0.862
351692.866	716485.682	4.003	351879.818	716560.797	-1.51	351698.851	716476.391	3.349	351708.468	716433.877	3.422	351766.979	716363.544	1.416
351690.709	716497.553	4.067	351875.665	716551.721	-1.48	351699.017	716467.201	3.418	351717.562	716429.282	2.862	351757.692	716359.365	2.015
351688.754	716507.731	4.107	351876.713	716539.596	-1.47	351705.311	716468.434	2.919	351726.282	716424.224	2.533	351748.354	716356.088	2.512
351687.07	716519.223	4.019	351866.649	716537.128	-1.26	351713.792	716470.329	2.445	351735.864	716420.622	2.108	351742.439	716354.024	2.921
351684.572	716530.026	3.947	351859.493	716535.586	-1.11	351722.43	716472.223	2.091	351730.39	716409.94	2.564	351739.51	716352.998	3.272
351684.02	716540.002	3.859	351848.259	716533.628	-0.84	351731.784	716474.464	1.498	351725.267	716401.881	2.962	351751.815	716348.423	2.468
351682.236	716548.178	3.942	351834.084	716530.771	-0.52	351742.4	716476.814	0.934	351723.614	716392.691	3.421	351763.463	716345.764	1.938
351683.681	716559.966	3.457	351821.462	716528.915	-0.25	351748.114	716477.654	0.494	351730.153	716394.952	2.803	351766.698	716334.555	1.987
351686.141	716569.231	3.107	351808.947	716527.408	-0.01	351754.055	716478.865	0.502	351738.263	716397.981	2.395	351759.639	716326.282	2.497
351677.919	716578.81	3.823	351794.917	716525.348	0.201	351769.351	716481.706	0.504	351746.66	716401.28	1.734	351755.685	716320.301	2.854
351679.269	716577.221	3.088	351782.515	716523.54	0.309	351784.421	716484.871	0.377	351756.409	716405.248	0.922	351753.835	716313.564	3.238
351685.432	716576.194	2.966	351773.26	716522.22	0.332	351796.574	716487.768	0.265	351764.508	716408.4	0.578	351761.58	716316.383	2.59
351691.841	716576.075	2.741	351764.364	716520.749	0.262	351809.06	716490.833	0.125	351776.149	716412.759	0.449	351770.016	716319.883	2.152
351699.892	716575.438	2.482	351760.618	716520.72	-0.02	351821.708	716493.32	-0.07	351782.329	716414.679	0.323	351775.483	716322.539	1.655
351706.912	716575.233	2.184	351780.023	716535.948	0.208	351835.761	716496.197	-0.39	351794.837	716419.202	0.316	351785.218	716326.789	1.344
351713.771	716574.684	1.653	351775.142	716537.584	0.109	351849.986	716498.964	-0.72	351807.67	716424.123	0.44	351795.609	716331.092	0.89
351723.016	716574.416	1.416	351771.434	716539.254	-0.19	351862.691	716501.454	-1.02	351821.558	716428.412	0.307	351805.273	716334.982	0.54
351734.237	716574.237	1.136	351764.069	716540.535	-0	351872.012	716503.034	-1.22	351834.619	716433.319	0.032	351818.391	716340.478	0.409

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H	V	D	H	V	D	H	V	D	H	V	D	H	V	D
351832.724	716346.393	0.286	351848.155	716260.386	0.564	351851.886	716165.363	0.545	351870.596	716096.479	1.047	351870	716018.415	2.909
351846.481	716352.549	0.12	351867.628	716266.436	0.32	351856.529	716167.218	0.606	351879.617	716100.17	0.596	351873.697	716012.769	2.838
351856.403	716356.975	-0	351884.381	716272.183	0.005	351868.592	716171.626	0.538	351888.825	716104.616	0.378	351872.6	716010.115	3.444
351867.926	716361.587	0.02	351898.153	716276.792	-0.23	351882.582	716177.652	0.402	351895.548	716107.713	0.229	351876.859	716003.01	3.379
351881.346	716366.464	-0.22	351913.453	716281.48	-0.5	351896.679	716184.175	0.164	351901.616	716110.913	0.277	351878.908	716004.163	2.813
351893.118	716370.608	-0.44	351925.635	716285.519	-0.75	351911.606	716190.604	-0.13	351915.046	716116.609	0.213	351885.217	716007.755	2.431
351903.853	716374.555	-0.69	351936.187	716288.472	-1	351923.785	716195.843	-0.38	351926.813	716121.546	0.013	351888.89	716009.847	2.181
351915.006	716378.679	-0.94	351945.562	716291.03	-1.25	351937.427	716201.07	-0.65	351938.451	716126.913	-0.22	351893.219	716012.462	1.67
351925.06	716382.617	-1.18	351953.23	716292.393	-1.45	351949.063	716205.479	-0.93	351948.709	716130.783	-0.41	351908.118	716021.545	1.153
351935.671	716386.874	-1.47	351947.425	716278.733	-1.33	351957.726	716208.978	-1.16	351962.24	716135.568	-0.67	351920.633	716028.764	0.824
351943.762	716362.815	-1.4	351951.951	716259.864	-1.5	351966.608	716212.345	-1.38	351972.32	716139.022	-0.88	351932.924	716036.139	0.502
351935.598	716356.163	-1.19	351942.087	716255.377	-1.14	351964.678	716195.735	-1.17	351981.367	716142.284	-1.07	351947.739	716044.555	0.173
351924.527	716349.765	-0.93	351925.66	716248.126	-0.69	351981.466	716180.937	-1.37	351987.295	716144.548	-1.22	351960.054	716051.874	-0.1
351911.849	716343.056	-0.65	351906.017	716241.788	-0.26	351972.044	716175.913	-1.11	351992.229	716146.341	-1.34	351970.332	716057.741	-0.26
351898.176	716335.853	-0.34	351891.022	716236.681	0.03	351963.094	716172.33	-0.92	351988.637	716134.1	-1.16	351982.666	716064.43	-0.43
351881.151	716326.471	-0.1	351876.022	716230.671	0.325	351948.775	716168.051	-0.63	351993.543	716119.615	-1.13	351992.438	716069.552	-0.67
351864.602	716317.408	0.109	351860.031	716224.329	0.539	351936.125	716160.781	-0.37	352005.587	716112.833	-1.33	352004.944	716076.15	-0.97
351851.042	716309.722	0.34	351847.62	716218.734	0.721	351920.481	716154.21	-0.09	351999.247	716107.605	-1.15	352018.454	716082.601	-1.3
351834.818	716300.774	0.553	351837.711	716214.771	0.953	351907.949	716148.881	0.16	351987.403	716102.06	-0.84	352030.934	716061.906	-1.27
351822.911	716294.46	0.697	351826.358	716209.49	1.325	351894.577	716143.568	0.389	351974.534	716096.127	-0.56	352022.651	716053.677	-1.03
351812.268	716288.781	1.002	351817.339	716205.521	1.569	351882.041	716138.766	0.413	351960.698	716090.083	-0.28	352011.297	716045.295	-0.74
351802.199	716284.399	1.334	351813.098	716203.387	1.952	351875.099	716136.196	0.356	351946.72	716083.919	-0.03	351997.789	716036.225	-0.46
351793.885	716280.316	1.601	351807.62	716200.853	2.427	351865.98	716131.055	0.596	351934.104	716078.778	-0.01	351980.428	716025.071	-0.12
351788.839	716277.803	1.869	351801.527	716198.19	2.826	351858.593	716127.109	0.81	351921.274	716075.047	0.204	351964.824	716014.418	0.217
351783.62	716275.469	2.424	351798.596	716196.924	3.129	351853.049	716124.568	1.016	351910.534	716070.265	0.454	351949.699	716004.396	0.642
351776.35	716272.196	2.794	351801.653	716188.453	3.014	351844.17	716122.559	1.67	351898.54	716063.996	0.838	351938.531	715997.146	0.879
351771.113	716269.751	3.293	351804.744	716179.663	2.965	351837.587	716120.22	2.228	351883.413	716055.783	1.304	351925.094	715988.293	1.211
351774.204	716262.07	3.239	351806.71	716174.445	2.978	351832.969	716118.01	2.538	351876.206	716051.998	1.575	351916.236	715982.288	1.572
351777.134	716253.931	3.217	351808.924	716168.254	2.988	351827.78	716115.394	3	351873.206	716050.486	1.695	351911.641	715978.826	1.816
351780.39	716245.616	3.228	351811.492	716161.229	2.929	351831.129	716106.689	3.035	351868.903	716048.643	2.181	351907.495	715975.471	2.373
351783.35	716237.877	3.223	351814.146	716153.63	2.901	351834.405	716098.44	3.079	351863.493	716046.259	2.467	351901.978	715971.088	2.668
351789.036	716239.912	2.689	351819.586	716156.075	2.494	351837.796	716089.631	3.08	351857.07	716043.172	3.083	351898.869	715968.924	3.056
351796.325	716242.613	2.36	351826.403	716158.103	1.955	351839.46	716085.139	3.09	351862.413	716034.338	2.911	351897.022	715967.621	3.561
351802.969	716245.265	1.673	351831.398	716159.274	1.489	351846.544	716087.403	2.491	351865.985	716026.871	2.942	351903.228	715959.112	3.597
351817.702	716250.187	1.244	351839.17	716161.128	1.179	351854.056	716089.972	1.979	351864.516	716026.203	3.434	351908.009	715957.364	2.941
351831.781	716255.002	0.856	351846.214	716163.217	0.715	351859.148	716092.055	1.439	351867.882	716018.718	3.433	351912.256	715952.31	2.884

2nd February 2003

H	V	D	H	V	D	H	V	D	H	V	D
351911.134	715949.426	3.282	351960.306	715897.583	3.098	352098.209	715940.235	-0.43	351875.434	716046.709	1.643
351915.528	715943.878	3.237	351964.79	715894.604	2.909	352102.276	715930.066	-0.23	351867.673	716065.571	1.605
351919.778	715942.83	2.87	351966.819	715896.397	2.513	352089.873	715924.035	-0.03	351859.69	716064.479	2.365
351920.027	715938.076	3.357	351975.165	715892.334	2.367	352085.97	715913.424	0.174	351854.39	716077.04	2.313
351924.37	715941.352	2.676	351976.225	715887.948	2.929	352072.271	715904.434	0.506	351858.555	716081.389	1.901
351929.712	715946.132	2.396	351981.354	715884.301	3.168	352068.424	715894.78	0.766	351862.381	716084.502	1.448
351933.929	715949.713	1.834	351985.491	715885.813	2.601	352065.229	715886.249	0.945	351855.952	716099.752	1.438
351939.566	715954.752	1.542	351987.996	715880.735	3.112	352062.46	715878.549	1.25	351846.682	716101.04	2.199
351950.115	715963.953	1.147	351993.342	715881.06	2.721	352058.686	715872.505	1.441	351840.977	716114.312	2.221
351960.813	715973.496	0.864	352000.707	715873.756	3.28	352055.958	715865.541	1.793	351844.929	716120.188	1.669
351973.684	715984.777	0.506	352002.813	715876.476	2.719	352053.274	715858.467	2.397	351850.273	716126.32	1.113
351983.535	715992.412	0.241	352005.093	715879.87	2.241	352051.869	715852.941	3.005	351843.677	716140.728	1.084
351993.88	716000.465	-0.06	352008.967	715873.492	2.75	352043.834	715855.47	3.178	351836.811	716138.267	1.753
352005.9	716009.894	-0.29	352012.216	715868.036	3.165	352039.492	715857.173	3.041	351830.864	716137.699	2.253
352018.016	716019.668	-0.55	352019.789	715864.927	3.115	352040.904	715863.013	2.389	351830.032	716149.36	1.946
352026.741	716026.128	-0.73	352022.87	715869.093	2.419	352042.99	715868.114	1.937	351825.341	716170.77	1.601
352035.545	716032.456	-0.95	352025.691	715871.496	1.895	352041.605	715875.034	1.497	351818.257	716173.509	2.274
352045.256	716039.051	-1.22	352026.337	715879.395	1.575	352036.251	715883.502	1.169	351812.921	716173.475	2.542
352062.12	716022.583	-1.24	352020.822	715892.126	1.359	352033.888	715895.618	0.771	351814.898	716185.5	2.266
352059.382	716017.745	-1.13	352027.337	715897.862	0.84	352029.501	715904.415	0.7	351818.086	716196.38	1.595
352055.168	716011.955	-0.98	352035.027	715908.576	0.651	352016.569	715913.36	0.874	351813.654	716211.716	1.652
352045.667	716001.599	-0.73	352037.317	715915.968	0.283	352001.309	715916.995	1.085	351805.703	716215.127	2.354
352035.826	715990.925	-0.46	352045.638	715924.67	0.154	351984.22	715921.078	1.285	351797.064	716217.209	2.683
352024.56	715978.265	-0.18	352050.745	715932.793	0.057	351961.618	715929.152	1.543	351791.204	716217.378	3.199
352015.402	715968.905	0.094	352057.788	715939.3	-0.06	351948.038	715938.623	1.664	351785.824	716230.855	3.24
352005.493	715958.717	0.388	352064.957	715944.981	-0.34	351935.992	715943.811	2.113	351792.573	716234.137	2.616
351995.692	715948.544	0.717	352070.726	715948.825	-0.47	351927.31	715948.644	2.412	351793.809	716248.251	2.404
351986.06	715938.468	0.96	352075.64	715954.562	-0.57	351918.09	715960.874	2.387	351796.227	716254.987	1.989
351978.688	715931.36	1.167	352082.968	715961.044	-0.72	351919.467	715968.47	1.784	351799.628	716261.774	1.617
351972.856	715925.86	1.313	352089.869	715966.455	-0.84	351910.491	715981.283	1.77	351791.557	716281.662	1.611
351966.712	715919.746	1.637	352098.718	715973.681	-1.06	351902.572	715983.121	2.442	351784.558	716281.154	2.178
351961.69	715914.91	2.021	352102.395	715976.187	-1.16	351894.233	715995.419	2.408	351776.88	716279.741	2.57
351958.021	715911.299	2.326	352102.638	715966.964	-1.08	351896.269	716003.435	1.752	351769.186	716277.134	3.012
351953.579	715906.595	2.695	352107.442	715962.968	-1.29	351884.505	716026.38	1.703	351766.326	716275.648	3.213
351951.9	715904.346	3.266	352106.003	715957.684	-0.91	351877.596	716027.28	2.358			
351959.366	715901.897	2.612	352102.821	715950.146	-0.69	351871.911	716039.327	2.362			

APPENDIX 2

Weather Data

Meterological Weather Data

JANUARY 2001

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	6.7	-5.1	1.8	4.8	18	SE-SEE	Light
2	8.9	1.5	0.0	5.1	15	SE>WSW	Light
3	5.5	0.9	5.0	10.9	23	SW-W>WSW	Light/Moderate
4	6.2	1.5	TRACE	5.1	13	W	Light
5	4.4	0.7	TRACE	5.9	13	W	Light
6	5.0	-0.5	3.2	5.4	13	W	Light
7	5.4	1.2	1.0	6.2	13	W	Light
8	7.2	0.5	0.0	7.3	14	SW-WNW	Light
9	2.6	-2.2	0.0	3.2	8	W-NW	Light/Gentle
10	3.9	-5.1	TRACE	5.9	15	W>N	Light
11	4.6	-3.4	0.0	6.3	14	N	Light
12	5.7	-0.5	0.0	2.5	12	W-NW	Variable/Calm
13	5.2	-0.1	0.0	3.3	12	SSW-W	Light
14	3.3	-5.0	0.0	2.6	8	WNW	Light/Variable/Calm
15	4.8	-7.6	0.0	4.0	13	W-NW	Light/Gentle
16	0.8	-5.6	0.0	3.7	7	W-NW	Light
17	3.5	-5.7	0.1	2.2	10	NW-NE	Light/Calm/Variable
18	3.3	-0.1	3.6	3.3	11	NW-NE	Light/Variable
19	3.8	-0.2	0.4	4.3	16	NE-NWN	Light
20	3.4	0.7	0.8	2.6	10	NW-NE	Light
21	5.0	-2.3	1.2	7.3	18	SE	Light
22	7.1	0.7	9.2	18.8	38	S-SE	Light > Moderate/Fresh, Occasionally Strong
23	8.2	4.2	5.4	12.5	38	S-SE	Moderate/Fresh, Occasionally Strong > Light
24	7.5	4.9	TRACE	18.4	46	S-SE>S-SW	Gale > Moderate, Fresh/Strong
25	6.5	-0.5	2.0	10.7	30	SW	Light/Moderate, Occasionally Fresh
26	5.9	2.5	0.2	15.4	28	SW-WSW	Moderate/Fresh, Occasionally Strong > Light
27	7.6	0.6	0.0	9.5	22	SW-W	Light/Moderate
28	5.8	-1.1	0.0	6.7	17	W	Light, Occasionally Moderate
29	6.5	-2.3	0.0	7.3	16	SW-W	Light/Gentle
30	4.8	-2.4	0.4	3.0	14	SE	Calm/Variable, Occasionally Light
31	7.5	0.4	0.0	2.7	10	NO DIRECTION	Variable/Light, Occasionally Calm

Meterological Weather Data

FEBRUARY 2001

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	5.0	-3.1	5.8	2.7	9	SE-S	Variable/Light
2	6.3	-0.6	6.6	3.3	13	W	Variable/Light
3	5.5	2.9	13.8	10.8	36	E	Variable>Moderate/Fresh
4	2.2	0.0	3.6	24.5	38	ESE	Fresh/Strong, Occasionally Nr.Gale
5	4.0	0.3	22.8	18.5	34	E	Strong>Moderate/Fresh
6	6.9	0.8	11.0	12.9	38	E>NE/SE	Fresh/Nr.Gale>Light
7	3.4	2.0	TRACE	8.9	42	SW-W>W-NW	Light/Gentle
8	4.9	-4.4	0.0	7.2	16	SW-NW	Light/Gentle
9	4.4	-3.9	0.0	6.2	14	W-NW	Light/Gentle
10	8.9	-4.3	8.4	7.3	22	SE>SW	Light/Gentle
11	10.1	2.5	1.0	18.0	47	SSW-SW	Moderate/Fresh>Strong, Nr.Gale
12	10.2	4.2	0.0	11.4	28	WSW-SW	Moderate/Fresh>Light
13	8.2	0.9	0.0	11.6	21	WSW-W	Gentle/Moderate
14	9.5	0.9	0.2	8.4	22	WSW-WNW	Light/Gentle
15	8.6	0.0	TRACE	7.5	18	W	Light/Gentle
16	8.5	-0.1	0.0	7.2	15	W	Gentle/Moderate
17	9.9	-0.5	0.0	7.2	15	WSW-W	Light/Gentle
18	8.1	-1.5	TRACE	9.6	23	WSW-NW	Gentle/Moderate
19	9.5	1.2	0.0	6.9	22	W-WNW	Light/Gentle
20	9.3	1.2	0.0	11.5	24	W-SW	Light>Moderate/Fresh
21	9.6	3.1	0.0	9.8	26	SW-WNW	Light/Gentle>Gentle/Moderate
22	9.5	0.3	TRACE	10.9	28	SW-W>NW	Light/Moderate>Moderate/Fresh
23	6.1	-2.2	0.6	11.3	36	N-NW>N	Light, Occasionally Moderate
24	3.6	-2.9	0.4	8.3	19	WNW-NW	Light, Occasionally Moderate
25	4.6	-0.8	1.7	6.7	18	W-NW	Moderate/Fresh, Occasionally Strong
26	1.5	-3.3	12.9	9.9	39	SE>NE	Strong, Nr.Gale>Fresh/Moderate
27	2.3	-0.3	0.0	19.2	44	N	Light, Occasionally Moderate
28	1.9	-5.1	0.0	6.1	20	NW-N	Variable/Light

Meteorological Weather Data

MARCH 2001

Date	Temperature 24hr Max	Temperature 24hr Min	Rainfall 24hr Total	Wind Mean Wind	Wind Max Gust	Direction	Comments
1	0.3	-5.8	3.7	4.9	15	W-NW	Light
2	-0.5	-9.6	0.2	3.5	9	W-NW	Light
3	1.5	-11.7	TRACE	8.0	27	SW	Moderate/Fresh
4	4.0	-9.2	0.0	10.7	20	SSW	Light/Moderate
5	7.1	-0.8	0.0	13.5	30	SW-WSW	Moderate/Fresh>Light/Gentle
6	5.5	-5.5	5.4	9.6	31	SE	Moderate/Fresh
7	12.6	0.7	TRACE	7.7	33	SE	Fresh/Strong>Light/Variable
8	11.7	2.9	0.4	7.7	20	SSW-SSE	Light, Occasionally Moderate
9	12.6	1.2	0.2	6.8	23	WSW-WNW	Gentle/Moderate
10	13.3	5.8	TRACE	4.8	19	WSW-WNW	Gentle/Moderate
11	11.0	3.1	17.2	8.2	20	WSW-WNW	Moderate>Light/Gentle
12	7.0	2.8	TRACE	10.2	26	W-NNW	Light/Moderate
13	9.0	2.4	TRACE	9.4	25	WNW	Light/Moderate
14	9.4	2.8	3.6	5.5	13	W-WNW	Light/Gentle>Variable
15	6.3	-0.5	1.0	3.6	11		Light
16	6.1	-2.7	0.2	7.8	18	NE-E	Light
17	6.1	-1.0	2.2	10.4	25	NE0-E	Light>Moderate
18	4.5	-0.1	0.2	7.8	24	E-NE	Moderate>Light
19	8.4	-2.8	0.0	5.3	18	WSW-W	Moderate>Light
20	6.5	-2.7	0.8	10.8	28	E-se	Light/Gentle>Light/Moderate
21	5.7	2.0	0.6	18.7	33	E-ESE	Moderate/Fresh>Strong
22	4.8	2.3	2.4	14.2	25	ESE	Fresh/Moderate
23	5.3	3.0	3.2	11.7	20	E	Light
24	4.7	3.8	1.6	12.6	22	E	Light/Moderate
25	6.4	3.2	0.4	12.2	22	ESE	Light/Moderate
26	5.8	2.8	TRACE	12.3	27	SE	Gentle/Moderate
27	5.6	2.6	3.6	13.6	30	SE	Moderate/Fresh
28	7.3	3.7	7.4	10.5	30	W-NW	Fresh/Strong>Light
29	9.0	4.1	TRACE	6.0	17	NW	Light
30	12.0	4.6	1.8	7.8	23	S-SW	Light>Moderate
31	13.5	6.5	TRACE	14.5	35	S-SW	Gentle/Moderate>Fresh/Strong

Meteorological Weather Data

APRIL 2001

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	13.8	2.7	1.4	9.4	30		NO WEATHER DIARY
2	12.7	7.0	0.4	10.3	35		
3	10.4	4.5	0.6	18.6	46		
4	12.0	0.1	0.0	11.7	31		
5	9.8	1.1	4.4	9.8	22		
6	7.3	3.7	2.0	8.8	23		
7	10.0	5.2	0.4	9.9	26		
8	11.7	0.8	TRACE	8.7	19		
9	12.5	2.6	2.0	8.0	21		
10	11.7	5.8	TRACE	9.0	25		
11	9.4	4.1	0.0	6.4	17		
12	6.3	-0.3	0.0	6.1	17		
13	11.1	-2.3	0.6	5.6	18		
14	15.1	4.7	0.8	14.1	30		
15	11.7	5.2	TRACE	9.6	25		
16	9.0	3.5	0.0	7.5	24		
17	11.5	0.9	0.8	11.0	28		
18	8.8	-1.1	TRACE	9.0	27		
19	10.1	2.3	0.2	11.3	30		
20	9.8	1.6	TRACE	6.3	19		
21	12.1	2.4	0.8	7.4	22		
22	7.9	5.6	2.6	7.7	15		
23	8.1	5.4	2.0	10.3	24		
24	10.1	-1.5	3.0	7.9	19		
25	7.6	4.9	5.6	8.1	17		
26	11.8	5.2	1.2	5.6	20		
27	13.5	3.7	1.6	8.0	18		
28	12.7	2.8	8.0	10.0	23		
29	8.9	3.9	0.2	7.0	16		
30	11.3	4.6	4.6	5.1	18		

Meteorological Weather Data

MAY 2001

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	16.4	3.3	0.0	6.2	116	SW-W	Light/Gentle
2	18.0	6.5	0.0	14.9	31	SW-W	Gentle/Moderate>Fresh/Strong
3	12.3	2.6	TRACE	5.4	17	W-WNW>ESE-SE	Light>Gentle/Moderate
4	13.6	3.8	TRACE	6.1	19	ESE	Light/Gentle
5	10.8	2.0	0.0	6.1	17	ESE-SE	Gentle/Moderate>Fresh/Strong
6	11.8	6.6	0.0	5.2	13	ESE>N	Gentle>Light
7	12.4	0.0	0.0	6.0	17	WNW>ESE	Light>Moderate
8	12.0	1.2	0.0	4.9	14	ESE>NNE	Light/Gentle>Light
9	11.7	2.0	0.0	8.4	19	ENE	Light/Moderate
10	12.7	5.4	0.0	10.8	23	NE>ENE	Light/Gentle>Moderate
11	14.0	5.5	0.0	5.7	13	ENE	Light/Gentle
12	16.8	3.9	0.0	5.1	15	W>NE-E	Light>Light/Gentle
13	13.4	4.8	0.0	7.0	16	NW-W>E	Light/Calm>Gentle/Moderate
14	10.4	7.3	TRACE	7.8	13	ENE	Gentle
15	9.7	7.3	5.4	5.5	13	ESE>SSE	Light
16	12.5	7.1	3.4	4.6	14	ESE>N	Gentle>Light
17	12.5	7.3	2.8	4.9	15	NNE-NE	Light/Gentle
18	16.2	3.9	0.2	11.0	28	SW-NW	Light>Moderate/Fresh
19	14.6	6.0	0.0	9.7	22	W-NW	Light/Moderate
20	17.8	5.2	TRACE	8.9	23	W	Light, Occasionally Moderate
21	19.3	10.0	0.0	5.7	16	SW-W>S	Light/Gentle>Gentle
22	22.2	6.7	0.0	5.7	15	W-SW>SE-S	Light/Gentle>Gentle
23	23.2	9.1	0.0	7.5	20	WNW>ENE	Light
24	15.0	7.7	0.0	8.3	22	SE	Gentle/Moderate
25	16.1	9.8	TRACE	5.1	15	NE-E>WSW-W	Gentle, Occasionally Moderate>Light
26	21.9	10.2	TRACE	8.5	23	WSW-W	Light
27	21.5	11.7	TRACE	11.8	26	SW-WSW	Gentle/Moderate>Gale>Strong
28	20.4	11.0	0.9	14.1	45	WSW-WNW	Fresh/Strong>Moderate
29	17.9	11.1	TRACE	17.8	41	W-SW>SE-S	Gentle, but Moderate
30	17.4	9.4	1.4	9.6	24	WSW-WNW	Light/Gentle>Moderate
31	18.1	6.6	0.4	12.2	29	WSW	Light/Gentle>Moderate

Meteorological Weather Data

JUNE 2001

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	16.0	9.5	4.6	12.8	31	WSW-W	Gentle/Moderate, Occasionally Fresh>Gentle
2	13.4	6.8	0.4	10.9	29	NNW-NNE	Gentle/Moderate, Occasionally Fresh
3	16.3	4.3	TRACE	10.1	22	W-NW	Gentle>Gentle/Moderate
4	19.3	9.2	0.0	14.5	29	W	Moderate, Occasionally Fresh
5	16.8	9.0	TRACE	15.6	33	W-SW	Gentle/Moderate>Fresh
6	16.5	10.1	1.2	9.3	19	WSW-WNW	Gentle/Moderate
7	12.6	6.9	3.6	5.9	25	W-NW>SE>NW	Light/Gentle>Variable/Gentle>Light
8	14.8	3.1	1.6	8.8	27	W-NW>SW	Light/Gentle>Gentle/Moderate
9	11.9	7.4	1.8	7.7	25	SW-W>E-SE>E-NE	Light/Gentle
10	14.9	1.7	0.0	5.9	21	NW>E-SE>NW	Light>Gentle, Occasionally Moderate
11	19.8	6.0	TRACE	9.6	22	W-NW>E-SE	Light/Gentle, Occasionally Moderate>Gentle/Moderate
12	14.4	9.7	0.0	6.7	18	ESE>S>SW-W	Light/Gentle
13	19.0	7.7	TRACE	8.5	22	SW-W	Light/Gentle, Occasionally Moderate
14	11.7	9.0	10.4	11.2	19	ESE>S>SW-W	Gentle/Moderate
15	10.5	9.0	11.0	14.9	26	E-NE	Moderate/Fresh
16	12.3	8.9	TRACE	11.9	26	E-NE	Moderate>Light/Gentle
17	13.6	8.3	0.2	7.0	20	N-NE>S-SW	Gentle/Moderate>Light/Gentle
18	14.2	3.4	2.0	5.4	20	W-NNW>W	Light>Light/Gentle
19	20.0	8.3	1.0	12.2	40	S-SW>E-SE	Light/Gentle>Moderate/Fresh, Occasionally Strong
20	18.5	12.5	0.0	18.5	34	W	Fresh/Strong>Moderate
21	19.7	7.8	0.0	9.6	22	WSW-NW>ESE-SE	Gentle/Moderate
22	14.7	6.0	0.0	7.5	19	SE	Light/Variable
23	18.1	6.2	TRACE	6.5	17	NE-N>SE>E	Light/Gentle>Moderate/Gentle
24	23.3	9.0	0.0	5.4	16	WNW-WSW	Light>Gentle
25	24.5	11.2	9.0	6.2	20	SW-NW>SW-W	Light/Gentle
26	14.3	12.3	9.4	8.7	18	NE-E	Light/Gentle, Occasionally Moderate
27	19.5	11.8	1.6	8.9	25	ENE-WNW-SW	Light/Moderate
28	18.4	12.0	0.6	12.3	29	SW-W>SSW	Light/Gentle>Fresh
29	20.7	11.3	2.4	8.7	26	SW-S	Gentle/Moderate, Occasionally Fresh
30	20.1	13.4	2.2	14.7	33	SW-W	Moderate/Fresh, Occasionally Strong

Meteorological Weather Data

JULY 2001

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	23.1	10.4	0.0	10.6	25	W-SW	Gentle/Moderate, Occasionally Fresh
2	25.3	15.2	TRACE	7.7	18	SW-W>S-SW	Gentle/Moderate>Light/Gentle
3	21.7	15.5	TRACE	5.0	14	E	Variable/Light>Light/Gentle
4	16.3	13.0	0.2	5.7	14	E	Variable>Light/Gentle
5	16.8	11.5	0.0	5.9	12	E	Light
6	17.8	11.6	1.4	5.9	14	E-SE	Light
7	20.2	14.3	0.0	4.0	17		Calm Throughout
8	23.6	13.7	0.4	5.4	14	W-NW	Light
9	18.9	13.0	TRACE	8.2	22	W-SW	Light/Moderate
10	16.1	9.5	7.6	8.0	22	S-SE>SW	Light>Moderate
11	16.2	7.0	5.6	11.8	26	WSW-NW	Gentle>Moderate
12	17.4	10.8	3.0	12.6	26	WSW-WNW	Moderate/Fresh
13	13.4	9.9	0.8	3.4	11	E-SSE	Light, Occasionally Gentle
14	13.3	9.2	1.2	5.9	14	E>N	Light/Gentle
15	14.1	9.5	4.0	4.6	16	SW-NNW>ESE-SSE	Variable/Light/Gentle
16	16.2	7.3	0.6	6.5	17	N>E-SE	Light>Light/Gentle, Occasionally Moderate
17	15.8	9.3	0.0	13.3	24	ENE-ESE	Light/Moderate
18	16.3	9.6	TRACE	12.7	30	NE-ENE	Gentle/Moderate>Fresh
19	17.3	9.9	0.0	7.8	20	N>NE-E	Light/Gentle>Gentle/Moderate
20	15.1	5.2	3.0	5.9	15		Mainly Calm
21	17.8	11.6	4.4	4.5	15	W-S	Light>Variable
22	20.7	12.6	0.0	10.5	29	W	Light/Moderate
23	21.1	8.3	TRACE	8.1	27	SW-WNW>SE	Light>Gentle/Moderate
24	21.5	10.8	0.4	9.6	24	WSW-W	Light/Gentle>Moderate
25	18.4	9.8	TRACE	3.6	11	WSW>SW	Light>Variable
26	19.5	12.1	0.4	5.6	16	W>S-SE>E-NE	Light
27	23.8	13.5	TRACE	4.5	16		Variable/Light
28	22.6	10.3	0.2	9.5	25	WSW-W	Gentle/Moderate, Occasionally Fresh
29	24.2	16.4	0.0	14.7	31	WSW-W	Light>Fresh>Moderate
30	20.4	10.7	10.4	10.4	27	WSW-W	Gentle/Moderate>Fresh>Light
31	19.4	9.3	TRACE	5.7	14	W-WNW	Light

Meterological Weather Data

AUGUST 2001

Date	Temperature 24hr Max	Temperature 24hr Min	Rainfall 24hr Total	Wind Mean Wind	Wind Max Gust	Direction	Comments
1	18.8	9.8	0.0	6.5	17	WSW-WNW	Light/Gentle>Variable/Light
2	18.5	11.8	3.0	3.7	113	WSW-W>E-ESE	Calm/Variable/Light>Light/Gentle
3	21.5	13.0	TRACE	8.5	24	W-WNW	Light/Gentle
4	19.9	8.2	4.6	7.5	22	SW-WNW	Light/Gentle>Variable/Light
5	19.3	7.7	3.8	9.6	23	WSW-WNW	Light/Gentle but Moderate
6	16.9	7.4	TRACE	7.3	15	W-NW>SE	Light/Gentle>Gentle
7	15.1	10.1	8.0	10.0	21	E-SE	Light/Gentle>Moderate
8	16.3	11.3	TRACE	7.3	23	N	Light, Occasionally Moderate>Variable
9	18.0	7.8	TRACE	6.6	19	W-SW>NW	Light/Gentle
10	19.9	6.2	3.2	8.0	23	W-NW>SE	Light/Gentle but Moderate
11	18.3	10.1	0.6	7.9	24	W-SW>NE-SE	Light/Gentle but Moderate/Fresh
12	20.7	13.6	0.4	11.0	23	W-SW	Gentle/Moderate, Occasionally Light
13	22.0	15.1	1.8	11.5	30	SW-W	Gentle>Moderate>Fresh
14	21.6	16.9	0.0	9.4	26	SW-W	Light/Gentle>Moderate>Light/Gentle
15	22.4	11.8	10.4	6.5	18	SW-W>E-SE	Gentle/Moderate, Occasionally Light
16	19.1	13.5	3.2	6.2	23	SW-NW	Light/Gentle>Light
17	19.5	10.6	0.0	7.3	19	SW-WSW	Variable
18	16.3	11.1	13.6	5.8	17	ENE-E	Variable/Light>Gentle
19	16.3	13.6	28.0	7.1	23	ENE-E	Gentle/Moderate
20	20.0	11.6	0.0	13.3	29	SW-W	Gentle/Moderate>Fresh>Gentle/Light
21	17.7	10.8	2.4	9.7	26	S>SW	Light/Moderate>Light, Occasionally Moderate
22	20.3	7.4	0.0	6.3	18	SE-SSE	Light/Gentle
23	17.7	8.4	0.0	4.3	17	W>E	Light>Light/Gentle, Occasionally Moderate
24	19.4	8.8	TRACE	4.1	13	W-NW>SE	Light/Gentle
25	19.1	10.6	1.0	4.7	16	W-NW	Light/Gentle but Variable
26	20.2	10.4	0.0	8.5	23	W-NW	Gentle/Moderate but Light
27	19.4	7.2	0.0	8.2	22	W-NW>E	Gentle/Moderate>Gentle>Variable/Light
28	19.0	8.6	TRACE	6.7	20	W-WNW>SW-W	Light>Gentle/Moderate
29	18.5	8.9	0.6	6.8	19	SW	Light/Gentle>Gentle/Moderate>Light
30	17.6	12.6	4.6	3.3	10	SW-W	Variable/Light>Light/Gentle
31	20.1	12.3	0.0	5.3	17	W-NW	Light

Meterological Weather Data

SEPTEMBER 2001

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	17.0	9.2	0.2	10.5	27	W-SW	Light>Moderate
2	19.4	12.3	0.0	14.2	30	W-WSW	Moderate/Fresh>Light
3	18.8	9.6	0.0	8.9	25	WNW-NNW>N	Gentle/Moderate>Gentle
4	17.3	8.2	0.6	6.7	21	NW-N>SW-W	Light/Gentle
5	21.9	7.9	0.0	6.3	21	W-NW	Light>Variable
6	17.2	8.9	1.2	12.3	29	WSW-WNW	Light/Gentle>Fresh>Moderate
7	18.1	12.2	1.0	11.5	38	W-NW	Gentle/Moderate, Occasionally Light but Fresh/Strong
8	15.3	6.2	0.0	9.6	29	NW-W	Light/Gentle>Moderate>gentle
9	16.3	8.0	0.0	9.1	28	W-NW	Gentle/Moderate, Occasionally Light>Moderate/Fresh
10	16.2	6.2	TRACE	8.1	20	NW-N>NW-W>SW-W	Light/Gentle>Gentle>Moderate>Light/Gentle>Gentle
11	20.9	11.8	TRACE	9.5	18	W-NW	Gentle/Moderate
12	15.7	11.2	1.0	13.5	33	W-SW	Light/Moderate>Fresh/Strong
13	14.5	8.9	0.6	8.9	24	SW>N-NE	Gentle/Moderate>Light/Moderate
14	17.9	6.3	1.2	10.5	26	W	Gentle/Moderate but Light
15	15.4	6.3	TRACE	10.4	28	W-NW	Light/Moderate, Occasionally Fresh
16	15.5	5.5	0.2	7.3	20	W-NW>N-NE	Variable/Light>Gentle/Moderate>Light
17	15.1	3.3	0.0	5.9	18	N-NW>SE-E	Light>Light/Gentle
18	15.1	3.0	0.0	4.5	17	NW>E-SE	Light>Light, Occasionally Moderate>Variable
19	16.3	3.5	3.4	6.7	21	W>SW>N-NE	Light>Light/Gentle, Occasionally Moderate
20	13.5	8.0	4.2	3.0	13	NE	Light/Gentle>Variable/Light>Calm
21	13.0	9.8	TRACE	2.7	11	SE	Calm>Light/Gentle
22	14.5	9.3	0.0	3.0	13	E-SE	Calm>Light/Gentle
23	14.6	5.3	TRACE	6.4	17	N-NE	Light/Gentle
24	14.7	10.3	1.4	10.7	21	NE>ENE-E	Gentle>Moderate, Occasionally Gentle
25	13.7	9.0	7.0	11.7	25	NE-ENE	Moderate, Occasionally Gentle
26	12.4	9.8	0.2	9.8	19	ENE-E	Gentle/Moderate>Gentle
27	14.1	9.4	2.4	9.6	19	NNE-NE>E-ESE	Gentle>Moderate
28	13.6	12.1	2.6	7.7	18	ESE>ENE-E	Moderate>Light/Gentle
29	18.3	11.0	1.2	5.3	17	E-ESE>SSE>W	Gentle>Variable>Light/Gentle
30	16.6	6.9	8.4	10.0	45	SE-S	Gentle/Moderate>Fresh>Moderate

Meteorological Weather Data

OCTOBER 2001

Date	Temperature 24hr Max	24hr Min	Rainfall 24hr Total	Wind Mean Wind	Max Gust	Direction	Comments
1	17.0	11.9	4.8	21.8	42	SW-WSW	Moderate/Strong, Nr.Gale
2	17.1	11.2	TRACE	26.0	49	SW-WSW	Strong, Nr.Gale>Gale>Fresh/Strong
3	16.0	10.2	TRACE	15.5	33	SW-WSW	Moderate/Fresh
4	16.2	7.7	0.6	8.9	21	W>S	Light/Moderate>Variable>Light
5	19.1	11.9	8.8	8.0	19	S-SE	Light/Gentle>Gentle/Moderate
6	17.6	9.5	0.4	10.2	25	SE-S>S-SW	Gentle/Moderate
7	16.2	9.0	16.8	11.2	40	S>SW>S-SE	Gentle/Moderate>Light>Light/Gentle>Fresh>Strong
8	14.9	10.0	2.6	8.5	23	SE>N-NW	Moderate/Fresh>Light/Gentle, Occasionally Moderate
9	15.7	10.0	1.2	12.1	28	W-NW	Gentle/Moderate>Moderate
10	15.3	10.9	TRACE	15.6	35	W-NW	Fresh, Occasionally Moderate>Moderate, Occasionally Fresh
11	17.6	10.1	0.2	13.8	38	SW>SW-W	Light/Gentle>Strong>Moderate
12	17.2	14.7	0.2	12.3	35	SW-WSW	Moderate>Fresh/Strong>Moderate
13	15.9	10.1	TRACE	8.0	22	SW-WSW	Moderate/Fresh>Light/Gentle>Moderate>Gentle>Light
14	14.8	8.1	9.2	4.6	13	ENE-ESE	Variable/Light>Light/Gentle
15	17.8	10.2	0.6	8.3	32	SE-S>SW-WSW	Variable/Light/Gentle>gentle
16	15.2	2.4	0.0	8.6	20	SW-W>SE-S	Light/Gentle>Light/Light>Light/Gentle>Gentle/Moderate
17	15.0	9.4	1.4	10.5	28	SE	Gentle/Moderate, Occasionally Light but Fresh
18	13.9	12.1	2.8	9.5	28	E-SE	Fresh, Occasionally Moderate
19	12.9	8.2	3.6	7.8	22	E-SE	Light/Gentle>Moderate
20	13.0	9.9	16.6	11.8	30	E-SE	Moderate/Fresh>Light
21	13.0	10.2	17.4	7.4	19	W>NE-E	Light/Gentle>Gentle/Moderate
22	12.5	11.5	4.6	10.0	18	E-SE	Gentle/Moderate, Occasionally Light
23	13.0	10.9	4.0	7.3	17	E-SE	Gentle/Moderate>Light/Gentle
24	15.3	9.9	0.2	7.1	22	S-SW>N-NW	Light/Gentle
25	15.7	6.2	2.4	10.6	29	W-SW<S>SE>SW	Variable>Light/Gentle>Moderate/Fresh
26	14.5	8.6	0.4	10.9	21	SW	Gentle/Moderate
27	14.0	8.0	0.0	14.7	33	WSW>W	Moderate/Fresh>Gentle
28	11.9	4.3	0.0	11.2	29	SW-W	Light/Gentle>Gentle/Moderate>Moderate/Fresh
29	14.5	6.6	TRACE	21.2	44	WSW>W	Fresh/Strong, Occasionally Nr.Gale
30	15.2	10.9	1.2	18.1	37	SW-W	Moderate/Fresh, Occasionally Strong
31	10.9	5.3	TRACE	11.1	29	SW-W	Gentle/Moderate, Occasionally Fresh

Meteorological Weather Data

NOVEMBER 2001

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	12.5	4.3	0.0	14.0	33	SW-W	Light>Moderate/Fresh, Occasionally Strong
2	14.1	9.2	0.0	17.5	32	W-SW	Moderate/Fresh, Occasionally Strong
3	11.9	5.6	0.0	12.4	28	W-SW	Moderate/Fresh
4	13.5	5.6	0.2	13.1	30	WSW-NW	Fresh>Light/Moderate
5	10.7	-0.2	1.6	11.7	34	W>SW	Light/Gentle>Moderate>Strong>Moderate
6	11.3	4.0	TRACE	9.9	30	W-NW	Light/Moderate but Fresh
7	9.3	2.1	0.8	8.5	29	SW-W	Light but Moderate>Variable/Light
8	4.0	0.8	1.6	11.1	30	N>NE-N	Gentle/Moderate
9	9.1	-0.4	TRACE	8.8	21	NW-W	Gentle
10	14.4	0.3	TRACE	15.0	29	SW-W	Moderate/Fresh, Occasionally Strong
11	14.3	9.1	2.2	12.5	26	SW-W	Moderate, Occasionally Fresh
12	7.2	7.2	0.0	10.5	27	SW>NE>N-NE	Light/Moderate>Light
13	6.9	-0.8	TRACE	7.0	15	NW-W	Light
14	9.8	-1.0	TRACE	7.3	21	W-WNW>SW-W	Light/Gentle
15	14.6	0.2	0.0	11.8	27	WSW-W	Moderate>Light
16	9.5	3.0	0.0	5.4	13	W-NW	Light
17	9.8	4.5	TRACE	6.1	13	SW-WNW	Light
18	9.0	4.5	7.2	4.3	14	W-WNW>SW-W	Light
19	9.6	6.7	0.2	4.1	11	NW-N>NE-SE>SW-W	Light/Gentle
20	11.0	4.4	TRACE	14.1	31	SW-W	Light>Moderate/Fresh
21	11.9	7.1	TRACE	15.2	38	WSW-WNW	Moderate/Fresh
22	5.4	3.6	0.6	9.4	25	w-W-NW	Gentle/Moderate, Occasionally Light
23	11.1	-1.6	2.6	9.0	19	W-SW	Gentle/Moderate, Occasionally Light
24	13.9	0.8	0.4	11.7	28	W-SW	Gentle/Moderate, Occasionally Fresh
25	10.0	9.9	0.0	16.4	39	W-SW	Moderate/Fresh, Occasionally Strong>Gentle/Moderate
26	7.6	-0.3	3.0	8.5	20	W-SW	Light, Occasionally Moderate
27	5.9	1.1	0.2	16.0	51	S-SW>W-SW	Fresh/Strong>Gentle/Moderate
28	10.2	0.5	0.6	9.9	24	SW-W	Gentle/Moderate>Light/Gentle>Moderate
29	11.0	1.3	4.6	9.5	21	SW>W>E	Moderate>Light/Gentle>Light>Gentle/Moderate
30	13.8	6.2	0.4	9.8	24	SE>S-SSW	Light>Light/Moderate

Meteorological Weather Data

DECEMBER 2001

Date	Temperature 24hr Max	24hr Min	Rainfall 24hr Total	Wind Mean Wind	Max Gust	Direction	Comments
1	9.3	8.2	0.0	10.2	28	SW-WNW	Light
2	6.0	-0.3	0.0	6.5	22	SW-W>S	Light>Variable/Light/Calm
3	8.2	0.6	8.8	12.6	40	S-SE	Variable/Light>gentle/Moderate>Moderate/Fresh>Strong
4	9.2	4.9	1.6	11.0	25	S>SW-W	Moderate>Gentle/Moderate
5	5.8	0.2	5.8	6.0	19	E>W	Variable/Light/Calm
6	6.4	-1.7	0.8	4.6	14	W-WSW>N-NE>S	Light/Gentle
7	11.7	-0.4	0.0	7.1	20	S-SW	Moderate>Light/Gentle
8	11.5	5.0	0.0	10.7	29	SW-W	Light/Gentle
9	9.7	3.2	0.0	4.9	14	SW-W	Gentle>Light
10	5.1	-3.0	0.0	2.7	7	NW-W	Light, Occasionally Calm
11	4.9	-3.6	0.0	3.3	10	WNW	Light
12	6.5	-2.5	0.0	3.5	10	W-NW	Light
13	4.1	-2.0	TRACE	2.5	6	NW-W>N	Light
14	5.2	-2.7	1.2	2.2	7	WNW	Light
15	6.8	2.9	5.6	4.3	12	NW>NE	Light
16	6.7	4.1	TRACE	4.6	14	N-NE	Light
17	6.1	2.8	0.4	3.8	8	NW-N>W	Light
18	6.8	2.9	TRACE	5.7	14	SW-NW>W	Light/Gentle
19	6.3	-1.1	0.6	8.3	21	W>SW>N-NW	Gentle>Moderate>Light
20	9.3	-2.1	1.8	11.1	25	W-SW>NW	Light/Gentle>Moderate
21	5.4	-0.2	TRACE	10.7	29	W-SW>NW	Moderate>Light
22	2.7	-0.2	TRACE	8.5	23	WNW-N	Light, Occasionally Moderate
23	7.7	-1.6	TRACE	10.5	25	WSW-W	Light/Moderate
24	10.2	1.1	0.0	12.7	33	WSW>WNW>NW>N	Moderate/Fresh>Light/Moderate
25	3.2	1.5	0.0	10.1	29	NW-W	Light/Moderate
26	3.1	-3.0	2.6	9.8	20	WNW-W	Light/Moderate
27	5.3	-1.9	5.0	5.2	26	N-WNW	Light
28	4.3	0.6	0.0	14.3	44	W-NW	Moderate/Fresh>Light/Moderate
29	2.7	-4.9	TRACE	7.0	19	NW	Light/Gentle, Occasionally Moderate, Occasionally Gentle
30	3.2	-4.1	0.0	6.6	23	NW-N>W	Light/Gentle
31	2.3	-4.3	0.0	8.2	18	WNW-WSW	Light

Meteorological Weather Data

JANUARY 2002

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	3.0	-1.7	0.0	10.0	24	W	Light, Occasionally Moderate
2	2.9	-7.5	0.0	3.7	12	W-NW	Light
3	2.9	-7.6	0.0	7.0	19	E-SE	Light
4	0.9	-6.2	3.2	2.9	9	S-SE>W-NW	Light
5	4.9	-6.3	TRACE	4.4	14	W-NW	Variable/Light>Light/Gentle
6	7.7	0.3	TRACE	6.8	15	W>SW>NW	Gentle, Occasionally Light
7	9.2	2.0	0.0	6.4	14	SW-W	Light
8	8.3	2.4	0.2	6.4	19	W-NW	Light/Gentle>Light/Calm
9	6.5	2.6	0.0	7.1	15	W>WSW	Light/Gentle
10	6.7	0.8	0.0	6.2	16	W-SW	Light
11	9.5	-2.2	0.4	6.7	18	W-NW	Light
12	10.4	2.0	TRACE	7.9	24	SW-W	Light
13	11.7	1.0	0.0	11.7	35	SW-W	Light
14	10.5	4.5	1.2	10.0	27	W-SW	Light/Gentle>Moderate
15	7.2	2.5	TRACE	12.8	27	W>SW>NW	Light/Gentle>Light/Moderate>Moderate/Fresh
16	9.8	3.4	1.6	12.5	26	W-SW	Light/Moderate
17	8.4	6.9	TRACE	9.7	22	SW-W>S	Gentle/Moderate>Light
18	7.5	0.7	2.4	10.6	28	SW-W>S	Gentle>Gentle/Moderate>Fresh
19	10.0	3.9	1.6	17.7	33	SW	Moderate/Fresh, Occasionally Strong>gentle
20	10.3	3.6	5.0	19.1	38	SW-W	Fresh/Strong, Occasionally Moderate
21	12.6	5.5	1.7	10.7	28	SW>SE>NE-N>SW	Gentle/Moderate>Light/;Gentle>Light, Occasionally Moderate/Fresl
22	8.8	6.6	6.8	24.2	50	SSW-SW	Moderate/Fresh>Strong, Nr.Gale>gale>Strong
23	7.9	4.6	25.1	7.5	22	W>SE	Gentle/Moderate>Light
24	5.2	3.8	TRACE	9.9	29	NE>N-NW>NE-NW	Moderate/Fresh>Light/Gentle>Gentle/Moderate>Variable>Light
25	6.3	-4.0	12.0	7.4	25	W-NW>W	Light>Variable/Calm>Gentle/Moderate
26	7.1	-2.1	8.6	7.5	23	W>SW-W>NW	Moderate/Fresh>Light>Light/Moderate
27	10.6	1.3	2.2	8.9	31	SW-NW>SE-S>SW	Light/Gentle>Fresh
28	9.6	3.4	5.0	29.1	52	W-WSW	Fresh/Strong>Nr.Gale>Gale>Moderate/Fresh
29	9.3	0.5	12.0	11.0	46	W>ESE>WSW	Gentle>Calm>Moderate, Occasionally Fresh
30	9.6	2.7	0.6	11.1	29	SW-NW>SE-S>SW	Gentle/Moderate, Occasionally Fresh
31	7.4	2.7	11.0	12.0	35	SW-W	Gentle/Moderate>Variable/Light>Fresh/Strong

Meteorological Weather Data

FEBRUARY 2002

Date	Temperature 24hr Max	Temperature 24hr Min	Rainfall 24hr Total	Wind Mean Wind	Wind Max Gust	Direction	Comments
1	11.2	2.7	6.4	15.9	39	W>S-SE>WSW	Moderate>Fresh>Strong
2	10.5	4.3	1.0	19.2	44	SSW>WSW	Strong>Gale>Moderate
3	8.7	4.0	5.6	12.7	39	SW>SW-W	Light>Fresh>Strong
4	7.6	1.1	4.0	9.5	36	SW-W	Light/Gentle, Occ.Mod.>Gentle/Mod.>Variable>Moderate/Fresh
5	9.0	1.1	2.6	9.4	33	SW-W>SE>W	Moderate/Fresh>Light/Gentle
6	8.6	1.9	3.4	8.1	25	SW-NW>W-NW	Light>Moderate>Light
7	11.0	0.0	4.6	13.9	40	W>SW>WSW-W	Gentle>Moderate/Fresh>Strong
8	11.2	3.7	9.4	15.1	39	SW-NW>S-SW	Moderate/Fresh>Gentle/Moderate>Fresh/Strong
9	8.4	4.8	0.0	13.5	35	SW-W	Fresh/Strong>Moderate>Moderate/Fresh>Light
10	11.3	1.1	5.6	10.0	34	W>SE	Light/Gentle>Moderate/Fresh>Strong>Light/Variable
11	10.0	3.9	5.0	17.4	43	SW-W	Variable/Light>Fresh Strong>Nr.Gale>Fresh/Strong
12	8.1	4.8	10.0	9.8	29	W>NE-E	Fresh/Strong>Light/Moderate>Light
13	7.1	1.3	0.0	6.5	19	NE-NW	Light
14	5.4	-3.0	0.0	10.4	26	SW	Light/Gentle>Moderate
15	9.9	0.6	0.0	8.9	19	SSW-NW>WSW-W	Light/Gentle>Moderate, Occasionally Gentle
16	10.1	2.9	0.0	15.7	34	WSW-W	Gentle/Moderate>Fresh
17	9.9	6.9	TRACE	11.0	23	SW-W>W	Moderate>Gentle>Fresh>Variable/Light>Moderate
18	7.9	0.6	0.4	15.5	36	W	Light>Moderate/Fresh>Fresh/Strong
19	6.9	1.3	4.2	9.7	43	NW>SE-W>SE-E	Fresh/Strong>Light/Gentle>Gentle/Moderate
20	7.4	1.4	3.0	11.7	38	WSW-WNW>NW	Moderate/Fresh>Light/Gentle
21	11.8	-0.6	0.4	15.0	38	W-SW	Light>Fresh/Strong
22	4.5	2.3	0.8	22.6	47	W	Strong>Fresh>Moderate>Fresh/Strong
23	5.2	-1.2	0.6	13.9	37	NW>SE-W>SE-E	Moderate/Fresh, Occasionally Strong
24	4.7	-3.0	2.0	4.2	17	NW-W	Light>Variable
25	8.4	-2.2	5.0	11.0	32	W	Variable>Calm>Moderate>Fresh>Variable>Fresh/Strong
26	7.0	2.4	3.0	10.0	30	WSW-W	Light/Light>Moderate/Fresh>Gentle
27	6.2	1.5	1.0	12.6	33	W>E	Gentle/Moderate>Fresh>Fresh/Strong>Light/Gentle
28	7.4	1.1	0.0	11.6	31	NE>N-NE	Moderate/Fresh>Light/Gentle

Meteorological Weather Data

MARCH 2002

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	7.1	0.1	0.2	7.5	18	NW>NE	Light/Moderate
2	8.0	-0.6	TRACE	8.4	25	W>NW	Light, Occasionally Moderate
3	11.4	3.4	0.0	14.4	25	W>NW	Moderate>Fresh>Moderate, Occasionally Fresh
4	10.8	5.9	TRACE	16.5	43	WSW>WNW	Moderate>Fresh>Strong>Gentle
5	10.7	0.6	1.2	21.9	43	WSW>WNW	Light>Moderate/Fresh>Strong>Nr. Gale
6	13.0	6.2	0.6	21.9	45	W-WNW	Strong, Nr. Gale>Fresh/Strong>Nr. Gale>Moderate/Fresh>Strong
7	10.7	4.1	TRACE	16.6	37	W-WNW	Moderate/Fresh>Light/Gentle
8	13.2	3.4	1.2	18.0	41	W-SW	Strong>Moderate
9	7.5	0.8	9.4	13.3	25	WSW-W	Moderate/Fresh
10	7.9	-0.5	4.5	16.2	52	SSW-WSW	Gentle/Moderate>Fresh/Strong
11	9.7	0.8	2.0	23.9	49	WSW-W	Fresh/Strong>Gale>Light
12	8.4	3.3	0.0	7.5	23	W>NW	Moderate/Fresh>Light/Gentle
13	9.9	-3.2	TRACE	5.9	14	W-WNW>NW>SW	Light>Variable>Light
14	7.1	-0.3	TRACE	11.8	37	NE	Variable/Light>Gentle/Moderate>Moderate/Fresh>Strong
15	6.2	3.8	5.6	23.4	39	SE	Fresh/Strong
16	11.7	4.3	0.8	8.5	25	SE>S>W	Strong>Light/Moderate
17	9.2	1.3	0.8	5.5	14	E-NE	Variable>Light
18	11.7	5.4	1.6	4.4	14	E>E-SE>W-NW	Light>Gentle>Light
19	5.0	3.1	0.6	4.8	14	NW>NE>S	Variable>Light/Gentle
20	5.7	2.8	15.4	7.1	18	SE>ESE	Variable/Light>Light/Moderate
21	6.0	4.1	5.0	7.4	17	E>SE>SE	Light/Gentle
22	6.1	4.1	TRACE	5.5	13	E-SE	Light/Variable>Light
23	10.1	3.1	0.0	7.3	19	S-SE	Light/Moderate
24	11.0	5.2	TRACE	6.7	23	SW>W>SW	Light/Variable/Clam>Gentle/Moderate>Light/Gentle
25	12.7	6.9	0.0	9.6	25	WSW-WNW	Light/Gentle>Moderate
26	12.6	-0.9	0.0	8.2	18	W	Light, Occasionally Moderate
27	13.9	3.3	0.0	12.9	30	W-SW	Gentle/Moderate>Moderate
28	15.2	2.9	0.0	7.2	22	WSW-NNW	Gentle/Moderate>Variable>Light
29	11.5	-0.3	0.0	5.2	16	W-SW>E-NE	Light>Gentle>Light
30	12.6	1.4	0.2	6.8	25	SW-W	Light/Variable>Light/Gentle>Moderate
31	14.5	5.3	TRACE	6.3	18	S-WSW	Variable>Light/Gentle

Meterological Weather Data

APRIL 2002

Date	Temperature 24hr Max	Temperature 24hr Min	Rainfall 24hr Total	Wind Mean Wind	Wind Max Gust	Direction	Comments
1	13.3	9.5	3.8	10.7	24	SSW-W	Gentle/Moderate
2	9.2	-0.3	2.0	8.1	19	SE>ENE>SSE	Light/Variable>Gentle>Moderate
3	12.7	6.3	0.0	10.7	25	E-SE>SE	Light/Gentle>Gentle/Moderate, Occasionally Fresh>Light
4	8.1	3.9	0.0	5.7	17	NW-NNE	Variable/Light>Gentle>gentle/Moderate
5	9.3	5.8	0.0	14.5	26	E-SE	Moderate/Fresh
6	8.6	5.8	0.0	9.5	22	E-SE	Moderate>Gentle>Variable/Light
7	11.8	-3.6	0.0	5.6	15	SE>E>NE	Light>Gentle>Moderate>Light
8	10.9	1.7	0.2	4.3	12	SW-WNW>E-ESE>N	Light/Gentle>Light
9	11.2	5.5	TRACE	5.0	15	SE-SSE	Light/Variable>Light/Gentle
10	10.3	6.8	TRACE	5.0	15	SE-S>SW	Light/Gentle
11	10.2	3.6	2.2	6.3	17	W>SW>NW	Light/Gentle
12	11.1	4.5	0.0	6.3	20	N-NE>NE>E-SE	Light/Gentle>Variable/Light
13	10.2	-0.8	0.2	6.7	17	W-NW>SE	Light>Gentle/Moderate
14	11.2	1.0	7.2	5.3	20	W-NW>E-NE	Light, Occasionally gentle
15	9.6	4.2	0.0	5.1	13	NW-W>E>W	Light
16	10.8	-1.1	0.0	6.0	19	ESE>SE-SSE	Light/Variable>gentle/Moderate>Gentle
17	11.0	0.9	TRACE	10.8	23	SE	Variable/Light>Light/Gentle>Moderate>Fresh
18	9.4	7.0	TRACE	10.2	19	ESE-E>NE	Light, Occasionally Moderate
19	12.0	2.0	0.0	5.1	20	SE	Variable/Light
20	13.4	0.8	1.8	5.3	17	S-SW	Variable/Light
21	14.9	10.5	1.0	11.4	33	SE-SSW>SW	Light>Moderate, Occasionally Fresh
22	16.5	11.1	TRACE	21.3	43	SW-WNW>E-ESE>N	Fresh/Strong, Nr.Gale>Moderate/Fresh
23	17.5	10.0	0.0	16.1	31	W	Moderate/Fresh>Fresh/Strong>Moderate/Fresh>Gentle
24	16.6	5.5	TRACE	11.6	27	SW-WNW>E-ESE>N	Variable/Light>Moderate. Occasionally Fresh
25	14.7	6.0	0.6	14.0	27	WSW-W>SW	Moderate, Occasionally Gentle>Moderate/Fresh
26	13.1	7.4	0.4	15.6	33	SSW-WSW>WNW	Moderate/Fresh
27	12.7	0.6	TRACE	10.3	27	WSW-WNW	Gentle/Moderate>Fresh
28	10.9	2.2	3.6	10.7	32	SE-SSE>WSW-NW	Light>Gentle>Moderate, Occasionally Fresh
29	10.3	0.7	TRACE	14.3	34	W-NW	Light/Moderate>Fresh, Occasionally Strong>Moderate
30	9.2	1.5	5.6	6.6	20	W>SE>NE>W	Light/Moderate

Meteorological Weather Data

MAY 2002

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	14.3	1.8	0.0	5.9	17	W-NW>SW-WNW	Light/Gentle
2	13.6	4.1	2.0	6.5	16	W-NW>E-NE>N-NW	Light/gentle, Occasionally Moderate
3	11.0	5.4	0.0	4.8	13	W>S-SE	Light
4	11.4	5.5	0.0	6.4	16	E-SE	Light, Occasionally Moderate
5	12.4	3.6	0.0	5.3	15	E-SE	Light
6	12.8	-0.3	TRACE	6.5	18	N-NE>E	Light, Occasionally Moderate
7	12.7	8.5	2.0	5.4	14	ENE-ESE	Light/Gentle
8	11.3	6.7	0.0	6.6	18	E	Calm>Light/Gentle, but Moderate
9	11.4	2.7	0.4	10.6	22	E-NE	Variable/Light>Moderate>Light
10	13.0	7.8	TRACE	4.3	19	E	Variable/Light
11	17.1	7.5	0.0	9.4	21	W-NW	Light, Occasionally Moderate
12	15.0	1.6	1.0	8.0	21	W-NW>SE	Light, Occasionally Moderate
13	12.9	8.7	2.6	10.1	34	ESE-SSE	Gentle>Moderate>Fresh>Light/Gentle
14	16.3	9.4	TRACE	16.0	39	SE>S>SW-W	Light/Gentle>Gentle>Moderate/Fresh>Strong
15	18.3	7.3	0.2	12.3	29	SW	Light/Moderate, Occasionally Fresh
16	19.7	11.2	0.0	9.2	25	WSW-W>ESE	Gentle>Moderate>Gentle
17	11.0	9.3	0.0	12.1	21	E	Moderate, Occasionally Gentle
18	12.1	8.7	2.8	10.3	20	E-NE>N-W	Gentle/Moderate
19	17.6	5.9	1.8	8.5	25	W>E>SW-S	Light>Gentle/Moderate, Occasionally Fresh
20	17.3	9.5	3.4	8.4	23	SE>s	Light/Variable>Calm>Light/Gentle>Gentle/Moderate>Variable
21	15.9	9.7	8.8	9.3	24	S-SE	Light/Moderate
22	17.5	10.5	1.8	11.5	30	S-SE>E	Light/Moderate, Occasionally Fresh
23	16.7	10.5	9.8	11.5	27	SE>SSW-WSW	Gentle/Moderate
24	15.7	9.2	2.4	14.0	31	S-SE>SW	Light/Moderate>Moderate/Fresh
25	15.4	9.1	0.3	13.4	34	no direction	Light/Moderate, Occasionally Fresh
26	15.4	9.4	3.2	10.2	19	SE>E	Light, Occasionally Moderate
27	14.0	8.2	0.8	6.6	21	E>SW	Light
28	15.4	6.1	1.0	10.8	28	E-SE	Light/Gentle>Gentle/Moderate, but Fresh
29	16.2	9.4	0.2	12.2	33	SE>SW-W	Light/Moderate>Moderate/Fresh, Occasionally Strong
30	16.0	6.5	0.2	10.8	29	SW>SW-W	Light>Fresh
31	17.8	4.7	TRACE	11.5	26	W	Light/Moderate

Meteorological Weather Data

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	19.2	8.8	2.4	5.7	15	S-SW	Light
2	14.9	10.6	1.8	7.5	31	E-NE>SW>E-SE	Light>Light/Gentle>Gentle/Moderate, Occasionally Fresh
3	16.5	11.6	6.6	7.8	21	SW>S	Light/Gentle, Occasionally Moderate
4	15.7	4.1	0.8	6.8	20	S>SSE	Variable>Light>Moderate
5	15.5	9.6	0.8	9.7	22	SE-NE	Light, Occasionally Moderate
6	15.5	11.6	0.0	12.1	23	NE-E	Gentle/Moderate, Occasionally Fresh
7	14.4	11.8	7.8	12.3	23	E-NE>SW>E-SE	Moderate
8	13.1	11.5	1.0	9.9	18	E-SE	Gentle/Moderate
9	14.2	11.5	11.6	8.9	26	E-SE	Gentle/Moderate, Occasionally Light
10	16.8	8.4	0.2	9.7	23	ESE-S>SSW-WSW	Gentle/Moderate
11	16.7	8.6	TRACE	10.6	25	SW-W	Light, but Moderate
12	14.9	6.5	6.6	7.5	24	W-SW	Light/gentle, Occasionally Moderate/Fresh
13	18.3	8.8	1.2	9.9	24	WSW-WNW	Light/Gentle>Moderate
14	16.1	8.3	12.2	6.5	25	ESE-W	Variable/Light>Light/Moderate
15	20.2	10.8	0.4	10.0	24	WSW-WNW	Gentle/Moderate>Moderate/Fresh>Light
16	19.5	10.1	5.2	7.0	12	ESE>SSW-W>S-SE	Variable/Light>Light/Gentle>Gentle/Moderate
17	21.1	12.5	0.0	16.8	39	SW	Light>Fresh/Strong>Moderate/Fresh
18	19.3	11.4	0.4	16.1	35	SW-W	Moderate/Fresh, Occasionally Strong
19	17.7	10.6	0.2	14.0	33	SW-W	Moderate/Fresh, Occasionally Strong>Light
20	18.5	8.2	0.4	5.2	20	ESE	Variable>Light/gentle, but Moderate
21	17.0	9.3	2.6	6.5	19	W>S>SW	Light>Light/Moderate>Variable/Light
22	19.4	11.7	1.2	9.5	28	SW-W	Variable/Light>Light/Moderate, but Fresh
23	18.0	8.9	TRACE	14.7	30	W	Moderate/Fresh>Light
24	17.1	8.7	TRACE	13.5	29	WSW>W	Light/Moderate, but Fresh
25	18.4	9.3	0.0	16.9	37	W-SW	Moderate/Fresh, Occasionally Strong
26	17.7	11.2	TRACE	16.3	36	W	Light/Moderate>Fresh>Moderate
27	17.2	7.0	1.2	11.2	29	W>NW	Light>Moderate, Occasionally Fresh
28	18.1	9.9	TRACE	10.6	22	W>NW	Light/Moderate
29	19.2	10.5	3.6	12.7	26	W	Light>Moderate/Fresh>Light
30	15.5	12.1	6.2	10.0	21	W-SW	Light/Moderate

Meteorological Weather Data

JULY 2002

Date	Temperature 24hr Max	Temperature 24hr Min	Rainfall 24hr Total	Wind Mean Wind	Wind Max Gust	Direction	Comments
1	15.0	9.8	3.2	8.6	21	SW-W	Gentle/Moderate, Occasionally Light
2	17.7	7.1	0.4	7.0	19	W>SW	Light, Occasionally Moderate>Variable
3	17.6	10.6	11.8	5.1	19	E>SE	Light/Variable
4	16.2	9.1	0.0	5.3	15	NE-SE>SW	Light>Light/gentle>Calm
5	15.4	6.5	0.4	7.2	17	SE-NE	Light/Variable>Light/Gentle
6	15.0	8.1	2.0	6.7	18	W-SW	Light/Gentle, Occasionally Moderate
7	18.3	7.3	7.2	8.5	22	W-SW>S	Light/Gentle, Occasionally Moderate
8	18.0	10.3	0.6	13.6	33	SE-SSE>SW-WSW	Light>Gentle/Moderate>Fresh, Occasionally Strong>moderate
9	16.6	7.9	0.6	5.1	16	DE	Light/Variable, Occasionally Moderate
10	19.7	8.6	TRACE	5.4	21	SW-W	Calm>Light/Gentle, Occasionally Moderate
11	19.8	8.6	0.2	11.1	28	WSW-W	Gentle>Moderate>Fresh
12	17.1	7.0	TRACE	5.1	18	W-NW>SSE-SSW	Light/gentle>Variable>Light/Gentle>Gentle/Moderate
13	17.3	5.7	TRACE	6.1	16	W-WNW>ESE	Calm>Light>Gentle/Moderate>Variable>Light/Gentle
14	20.7	7.6	0.2	8.0	21	W-NW>WSW-W	Light/gentle>Moderate>gentle
15	23.5	14.2	0.0	10.1	21	W>E	Light/Moderate>Light
16	16.2	13.1	TRACE	5.8	17	ENE-E	Light/Variable>Gentle>Light
17	15.8	12.9	0.4	6.9	18	NE>ENE	Light/Variable>Gentle>Moderate
18	19.6	12.2	3.2	5.4	14	E>SE	Light
19	15.9	12.1	11.6	5.0	17	no direction noted	Moderate>Light/Variable
20	15.0	11.0	7.8	8.1	25	E>NE	Light>Moderate>Light
21	17.9	9.2	1.0	5.3	14	NW>SE>WSW	Light
22	22.4	9.2	11.6	10.8	24	W-WNW>ESE	Light, Occasionally Moderate
23	14.7	12.0	4.0	6.2	19	W-NW>NE>SW-NW	Light/Gentle>Gentle/Moderate>Light/Gentle
24	19.8	8.8	1.0	9.0	21	W	Light/Moderate
25	19.1	11.3	0.0	12.7	30	W	Light>Fresh/Moderate
26	20.6	9.8	0.0	12.8	24	W	Moderate>Fresh
27	21.2	14.5	0.0	9.3	21	W-SW	Light>gentle>Moderate
28	20.8	11.8	19.2	10.4	27	SW-W>E	Light/Moderate, Occasionally Fresh
29	16.1	13.4	0.8	8.6	20	ENE	Light, Occasionally Moderate
30	18.1	14.0	57.4	3.5	13	E>W	Light **THUNDERSTORMS*
31	20.5	14.1	1.2	8.1	26	E	Light/Variable>Calm>Light>Moderate

Meterological Weather Data

AUGUST 2002

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	20.3	16.0	0.0	11.2	22	ENE-ESE	Gentle/Moderate>Light/Gentle
2	20.5	9.9	5.0	7.8	25	ENE-E>WNW-NW>NI	Light/Gentle>Moderate
3	16.7	15.1	0.2	8.5	26	E-NE	Light/Gentle
4	17.7	13.5	TRACE	3.9	12	ENE-ESE	Light/Gentle, Occasionally Light/Variable>Calm
5	18.9	13.1	0.2	5.0	13	W-NW>E-SE	Light, Occasionally Calm>Light/Gentle
6	19.3	13.1	7.8	5.2	17	W-NW>S-SE	Light>Variable
7	22.6	14.9	0.2	7.7	19	WSW-W	Gentle/Moderate
8	16.7	10.0	9.0	7.3	20	W>SE-E>NE	Light/Gentle>Moderate
9	13.7	11.6	4.6	4.4	21	NE>N>NE-E	Light/Gentle, Occasionally Moderate>Light, Occasionally Calm
10	17.1	11.4	0.0	4.7	11	W>SE>S	Light/Gentle
11	15.8	12.6	6.2	4.2	13	SE-E	Light/Variable>Light/Gentle
12	20.9	11.7	0.0	7.4	25	W-SW	Light/Gentle>Moderate>Fresh
13	23.5	14.1	2.6	9.6	25	SW-W	Gentle, Occasionally Moderate>Fresh>Gentle
14	19.5	12.5	0.6	5.8	20	W>E-SE>S	Light/Gentle
15	20.6	14.2	0.0	12.4	33	SW>SW-W	Light/Variable>Gentle/Moderate>Fresh/Strong>Light/Gentle
16	19.6	9.1	0.0	4.9	14	W-NW>E-SE	Light>Gentle/Moderate
17	23.3	11.4	0.4	10.1	22	E-SE>SE-S>S-SW	Gentle/Moderate
18	19.1	15.6	1.6	4.8	15	W-NW	Light/Variable>Light>Gentle/Moderate
19	18.2	9.9	0.0	5.1	16	W-NW>SE-SSE	Light>Moderate
20	18.2	9.0	0.0	4.3	15	SE-E	Light/Variable>Light
21	17.7	9.1	0.0	5.5	16	W	Light>Gentle>Moderate>Light/Variable
22	20.2	9.9	11.2	5.2	18	W-NW>NE-SE>W	Light>Light/Gentle>Light
23	17.7	13.0	12.6	5.8	12	W	Light/Gentle
24	19.7	13.6	3.4	4.7	12	W-NW>NE-SE>W	Light>Gentle
25	17.3	12.9	TRACE	4.2	13	W>SE>E-SE	Light>Gentle>Variable
26	18.4	9.4	0.0	5.2	16	W-NW>SE-SSE	Light>Light/Gentle>Light/Variable
27	20.7	8.9	TRACE	6.7	12	W-WNW>ESE-SE	Light/Gentle
28	22.2	14.4	0.0	8.9	24	N-NW>W-SW	Light/Gentle>Moderate, Occasionally Fresh
29	19.6	14.5	6.0	14.4	33	SW-W	Gentle/Moderate>Fresh>Strong>Fresh
30	17.4	12.0	16.6	6.7	18	SW>E-SE>SW>NW	Light/Moderate>Light/Moderate
31	17.5	7.3	0.0	10.7	28	SW-W	Gentle/Moderate>Gentle

Meterological Weather Data

SEPTEMBER 2002

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	17.6	6.0	0.0	9.5	22		NO WEATHER DIARY
2	20.4	11.0	0.0	9.3	22		
3	20.4	7.1	0.0	5.1	15		
4	17.3	12.7	TRACE	5.6	12		
5	16.9	11.2	0.2	10.7	28		
6	17.0	7.8	0.2	10.2	26		
7	15.0	8.7	TRACE	7.3	15		
8	15.7	10.5	10.6	10.5	27		
9	16.1	7.7	9.6	8.1	26		
10	17.8	13.3	0.0	9.7	24		
11	20.7	5.2	TRACE	4.9	14		
12	16.7	10.5	TRACE	6.1	13		
13	16.7	13.7	0.0	6.4	16		
14	16.0	12.4	0.2	3.9	16		
15	15.5	12.7	0.2	4.0	15		
16	16.9	11.4	TRACE	4.1	14		
17	17.8	10.6	0.0	4.5	13		
18	14.1	12.0	0.0	5.8	13		
19	15.2	10.9	0.0	4.9	14		
20	16.9	11.0	TRACE	4.3	11		
21	17.4	9.8	TRACE	5.5	18		
22	15.4	7.1	0.0	7.0	22		
23	15.1	5.6	0.0	4.4	10		
24	17.6	4.6	0.0	5.3	10		
25	14.9	4.6	0.8	9.9	25		
26	16.7	6.4	0.0	7.5	15		
27	17.2	8.0	0.0	6.8	14		
28	15.2	11.4	0.0	5.9	15		
29	18.5	11.4	TRACE	6.9	20		
30	20.2	9.7	TRACE	4.2	17		

Meterological Weather Data

OCTOBER 2002

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	18.7	8.5	0.0	3.5	11		NO WEATHER DIARY
2	19.8	7.7	0.2	4.4	21		
3	17.9	9.3	0.2	10.5	25		
4	15.3	5.7	0.6	10.4	25		
5	18.4	9.9	0.0	8.2	19		
6	14.9	5.6	0.0	3.5	10		
7	14.1	4.7	1.0	4.7	16		
8	14.3	9.1	0.2	11.1	28		
9	14.0	11.2	1.0	15.2	26		
10	13.0	11.0	0.2	15.5	28		
11	12.2	11.2	28.6	15.9	30		
12	10.3	9.7	28.0	15.3	32		
13	10.9	1.6	7.8	7.7	25		
14	11.0	5.8	8.2	11.0	27		
15	10.7	6.5	6.0	10.4	25		
16	10.6	3.6	TRACE	5.5	14		
17	10.9	2.5	TRACE	6.5	19		
18	8.9	3.1	0.0	6.9	19		
19	9.0	-1.1	0.0	7.7	19		
20	7.1	-2.2	15.2	5.8	27		
21	8.3	2.3	36.4	18.5	36		
22	7.6	6.7	3.2	18.5	38		
23	6.0	4.9	0.2	11.7	25		
24	8.4	0.2	10.6	9.0	22		
25	9.7	3.4	2.4	5.2	28		
26	11.3	2.9	17.6	10.2	30		
27	8.4	4.5	TRACE	15.0	34		
28	9.5	1.4	TRACE	9.3	22		
29	7.3	2.8	0.6	3.5	14		
30	9.6	-0.1	0.0	5.6	15		
31	10.8	0.9	1.4	4.2	11		

Meterological Weather Data

NOVEMBER 2002

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	11.5	4.0	3.2	3.8	11	ENE-ESE>NNE-NE	Variable/Light>Light/Gentle
2	11.6	9.2	15.6	12.8	44	NW-N>ESE-SSE	Light>Moderate>Strong, Nr. Gale
3	12.6	5.7	TRACE	9.9	33	SSE>SSW-WSW	Strong>Gentle/Moderate>Gentle
4	11.9	5.2	TRACE	7.1	17	SW-W	Light, Occasionally Moderate>Light
5	13.8	6.9	3.0	6.7	17	SW-WNW>S-SE	Light
6	11.8	8.3	0.0	12.2	31	WSW-W	Gentle>Moderate, Occasionally Gentle
7	9.7	3.0	0.0	12.6	24	WSW-W	Moderate/Fresh>Gentle/Moderate
8	9.6	3.2	0.0	7.6	22	W-SW>WNW-N	Moderate>Light
9	7.5	1.6	3.4	4.0	11	NNW>W>N	Light
10	9.6	-1.3	0.2	7.2	19	SW-W	Variable/Light
11	10.4	4.8	0.6	12.5	38	SSW-WSW	Gentle/Moderate, Occasionally Fresh
12	7.6	2.4	8.4	7.6	24	SW>W-SW	Moderate>Light/Variable>Gentle/Moderate>Light/Gentle
13	10.4	1.5	6.4	5.6	23	SE	Variable/Light>Light/Gentle
14	10.1	4.9	15.0	20.3	39	ENE-E>NNE	Fresh/Strong>Moderate
15	8.9	6.5	2.6	8.0	23	NNE>WSW-W	Moderate>Gentle
16	7.7	0.7	TRACE	4.2	12	WSW-WNW>WNW	Light/Gentle>Variable/Light
17	6.8	-1.9	0.0	3.7	9	NNW>W>N	Light, Occasionally Gentle
18	7.8	0.0	0.0	1.6	8	N>SE	Variable>Light, Occasionally Gentle
19	10.0	-0.5	2.6	8.9	22	SE	Light/Gentle>Gentle/Moderate
20	10.0	5.7	17.2	11.6	27	SE>SSE	Light/Gentle>Moderate, Occasionally Gentle/Fresh
21	10.2	7.1	8.8	19.0	38	SE	Light>fresh/Strong>Moderate/Fresh
22	10.3	7.7	5.0	11.5	24	SE	Moderate, Occasionally Gentle
23	10.2	7.1	TRACE	9.1	21	SE>E>S	Gentle/Moderate, Occasionally Gentle
24	9.7	5.4	0.0	6.3	19	SE-SSE	Gentle/Moderate>Light/Gentle, Occasionally Moderate>Light
25	9.0	2.0	0.6	2.7	9	ESE-S	Light/Variable>Light
26	10.0	1.3	3.0	5.4	17	SE>NE>E	Light/Gentle, Occasionally Moderate
27	9.5	6.9	5.6	12.9	32	SE-SSE	Gentle/Moderate>Fresh/Strong
28	9.8	4.2	0.2	8.2	23	SE>S	Gentle, Occasionally Light/Variable
29	10.2	1.5	TRACE	1.7	7	W-NW	Light/Variable>Light
30	8.6	4.0	5.2	3.3	13	SE-SW	Light/Variable>Light/Gentle>Light/Variable

Meterological Weather Data

DECEMBER 2002

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	9.4	6.9	11.6	11.6	29	S-SE>SW-S>SE-S	Light/Gentle>Gentle/Moderate>Moderate/Fresh
2	9.4	7.1	13.0	7.0	19	SE>N-NW	Light
3	9.9	7.0	4.8	8.3	18	N>SW	Gentle>Moderate
4	8.1	7.5	1.6	10.0	21	SSE>NW	Gentle>Moderate
5	9.6	5.0	0.6	9.2	23	N-NW>E	Light
6	8.2	7.7	3.2	10.0	20	ESE-SSE	Gentle/Moderate
7	6.7	5.9	1.8	13.1	26	ESE-SE	Moderate/Fresh
8	7.5	4.5	0.2	17.8	30	E-SE	Fresh, Occasionally Strong
9	7.3	5.7	0.2	17.6	30	SE>E-SE	Moderate/Fresh
10	6.0	3.8	TRACE	16.6	28	E	Moderate/Fresh, Occasionally Strong
11	6.4	4.8	0.4	15.5	33	ESE>SE	Moderate/Fresh
12	6.6	4.0	TRACE	14.7	27	SE	Moderate/Fresh>Moderate
13	6.8	5.6	3.2	6.1	19	ESE>ENE>ESE>W	Moderate>Variable>Light
14	6.4	4.0	0.6	11.0	25	E-ESE	Gentle/Moderate>Fresh
15	5.9	4.3	7.0	12.4	22	E-NE	Light/Moderate
16	3.7	3.1	1.8	6.3	20	NNE	Light/Gentle
17	3.0	-2.5	0.0	6.1	13	W-NW	Light/Gentle
18	5.8	-1.5	0.0	3.8	13	WSW-WNW	Light
19	-0.8	-4.2	0.0	2.8	7	WNW-NW	Light
20	2.1	-5.5	0.0	3.3	8	W-NW	Light
21	6.7	-3.1	4.1	4.3	22	W-NW>ESE-SSE	Gentle/Moderate
22	7.3	0.4	2.6	7.2	23	SE>W-SW	Gentle/Moderate>Light>Calm
23	9.0	4.2	9.6	11.0	27	SE-SSE	Gentle/Moderate>Fresh
24	11.1	7.0	0.3	10.5	26	ESE-SSW	Gentle/Moderate
25	11.1	6.7	1.3	3.8	13	NO DIRECTION	Variable>Light/Gentle
26	8.4	5.5	14.4	10.3	22	E-ESE>ENE	Gentle/Moderate>Gentle
27	7.5	7.0	3.4	5.5	16	NNE-NE>W	Light/Gentle
28	9.0	4.2	0.0	8.5	17	WSW-W	Gentle, Occasionally Moderate
29	7.7	2.2	1.8	8.3	26	W-NW	Light>Variable>Light>Moderate/Fresh
30	6.0	4.0	1.8	12.6	25	E-ESE	Fresh>Moderate>Light/Gentle
31	5.3	1.9	0.2	8.1	19	SSE-S	Light/Gentle>Moderate

Meterological Weather Data

JANUARY 2003

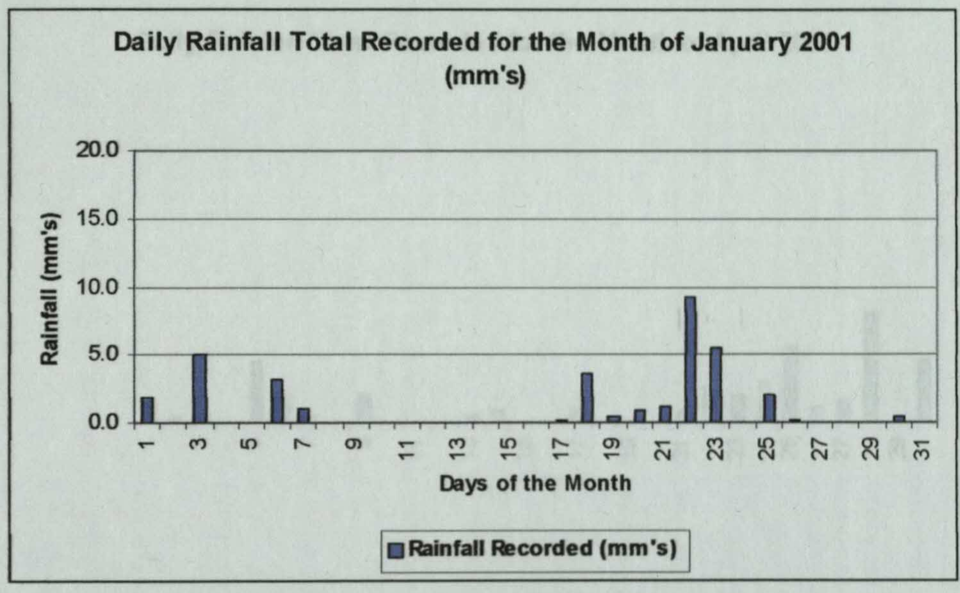
	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	5.9	0.1	15.4	12.2	27	SE	Light>Moderate/Fresh>Moderate
2	4.5	3.0	3.2	15.9	31	NE-E	Moderate/Fresh>Light/Moderate
3	2.7	-1.8	0.0	6.7	19	NW-NNE	Light Occasionally Moderate
4	4.2	-1.9	0.0	7.4	16	NW	Light Occasionally Moderate
5	3.9	-2.2	TRACE	5.1	10	W-NW	Light
6	3.6	-4.4	0.6	3.7	8	W>NW-N	Light
7	2.5	-5.0	0.6	2.9	8	W-NW	Variable>Light
8	4.7	-4.0	0.2	8.2	24	NE	Light/Moderate
9	5.3	2.0	TRACE	7.3	20	NE>NW	Light/Gentle>Gentle
10	5.4	-0.5	0.0	6.9	15	NW>W>W-NW	Gentle>Light
11	3.8	-3.0	TRACE	8.0	17	W	Light/Gentle>Gentle/Moderate
12	10.1	-2.2	TRACE	14.7	30	W>SW	Gentle/Moderate>Fresh>Moderate/Fresh
13	11.3	3.8	TRACE	19.3	35	W	Moderate/Fresh>Strong>Gale
14	10.8	9.7	TRACE	20.9	45	W-SW	Moderate/Strong>Gale
15	8.2	6.2	5.0	25.5	49	SW-W	Strong>Gale>Fresh/Strong>Gale
16	10.3	4.4	2.4	19.2	38	SW-W	Moderate/Fresh>Fresh/Strong>Gale
17	8.0	6.4	1.2	22.7	50	SW-W	Fresh/Strong>Gale
18	7.3	3.0	4.0	11.7	32	SW-W>S-SE	Moderate/Fresh>Light/Gentle Occasionally Moderate
19	5.9	4.3	0.0	5.1	16	SE>NW-W	Light/Calm>Light/Gentle
20	7.7	-0.8	12.4	8.0	23	SW-NW>SW-W	Variable/Light>gentle/Moderate
21	6.4	1.1	8.4	2.5	10	N	Variable>Light
22	5.7	2.4	2.0	9.4	33	N-NW	Light/Gentle>Moderate/Fresh
23	10.3	-0.2	TRACE	5.3	20	W-SW	Light/Gentle>Light
24	11.3	0.8	2.2	16.7	31	SW	Moderate/Fresh Occasionally Strong
25	9.5	5.9	0.6	17.8	41	WSW-W	Moderate/Fresh>Strong
26	14.1	5.2	0.0	17.7	37	W	Fresh/Strong Occasionally Moderate
27	12.6	8.9	0.2	19.3	45	SW-W	Fresh/Strong Occasionally Moderate
28	7.3	3.1	TRACE	17.8	39	W-NW	Strong>Fresh/Strong>Moderate>Gentle
29	5.4	3.3	TRACE	11.3	34	N-NNW	Moderate Occasionally Fresh>Light
30	0.9	-2.2	TRACE	12.7	37	W>N>NW	Gentle>Gentle/Moderate Occasionally Fresh>Gentle
31	2.3	-3.4	0.3	9.3	21	W-NW>SW-W	Gentle>Gentle/Moderate

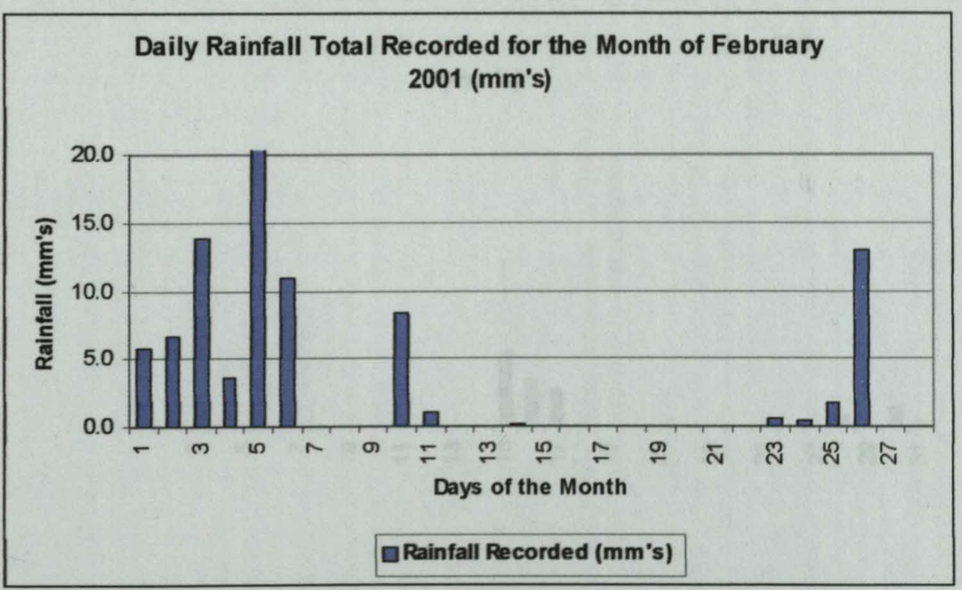
Meterological Weather Data

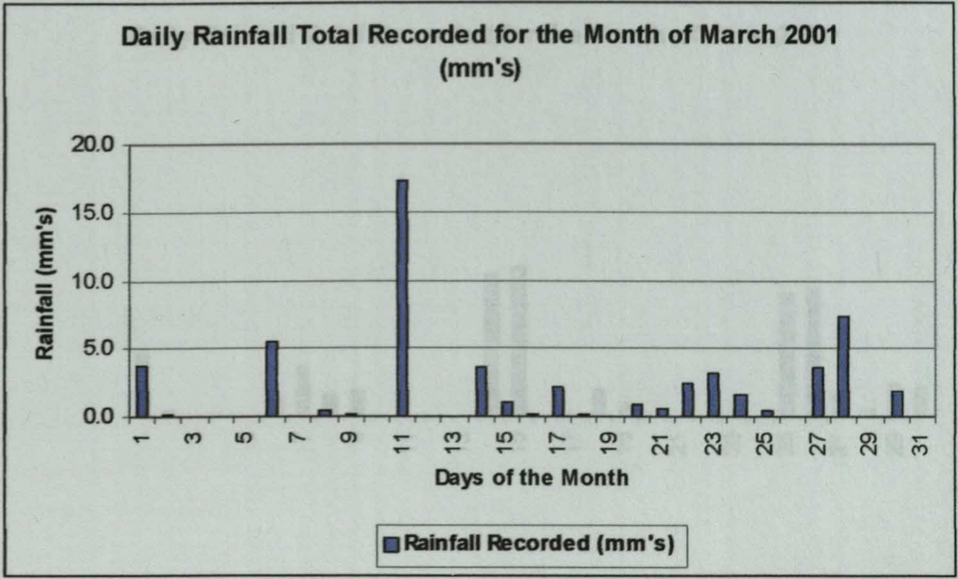
FEBRUARY 2003

	Temperature		Rainfall	Wind			
Date	24hr Max	24hr Min	24hr Total	Mean Wind	Max Gust	Direction	Comments
1	5.9	-1.4	3.2	10.4	24		NO WEATHER DIARY
2	2.5	0.0	2.0	13.5	29		
3	3.1	-0.8	0.6	12.9	27		
4	3.1	-1.5	0.0	12.0	35		
5	4.4	-3.4	TRACE	7.6	19		
6	7.5	-4.3	TRACE	8.6	20		
7	8.4	2.3	0.0	11.3	27		
8	10.3	5.8	1.2	10.3	26		
9	8.5	5.7	TRACE	6.7	19		
10	6.8	-3.3	2.2	6.4	24		
11	9.9	1.6	0.0	4.9	15		
12	9.1	0.9	0.0	3.7	10		
13	6.5	2.9	0.8	5.1	16		
14	5.5	-4.3	0.0	2.1	7		
15	6.3	-5.8	0.0	3.0	9		
16	5.1	-6.2	0.0	4.2	15		
17	4.7	-3.9	0.0	3.0	9		
18	4.7	-7.5	0.0	8.8	24		
19	5.5	0.1	0.0	12.7	26		
20	6.8	3.1	0.0	8.3	20		
21	9.1	-2.0	0.0	25.3	8		
22	5.5	0.9	0.0	9.8	26		
23	10.7	4.0	TRACE	12.0	29		
24	9.5	-1.5	0.0	4.4	16		
25	8.4	0.9	0.0	11.0	22		
26	7.1	5.1	0.0	10.9	21		
27	7.1	5.0	3.0	10.0	18		
28	9.6	4.9	2.0	8.7	24		

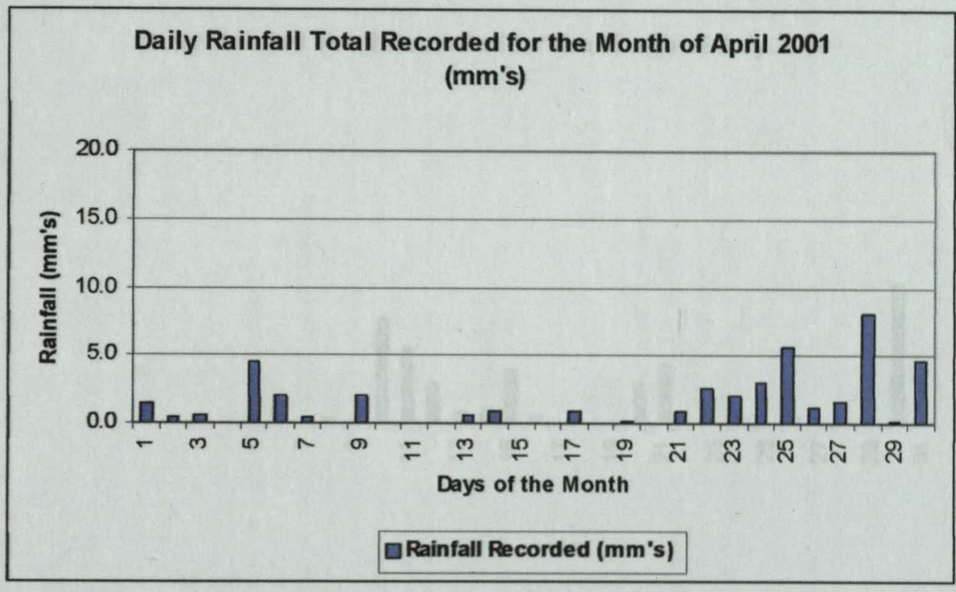
Appendix 2
Daily Rainfall Totals Recorded (mm's) for January 2001 – April 2003 Inclusive

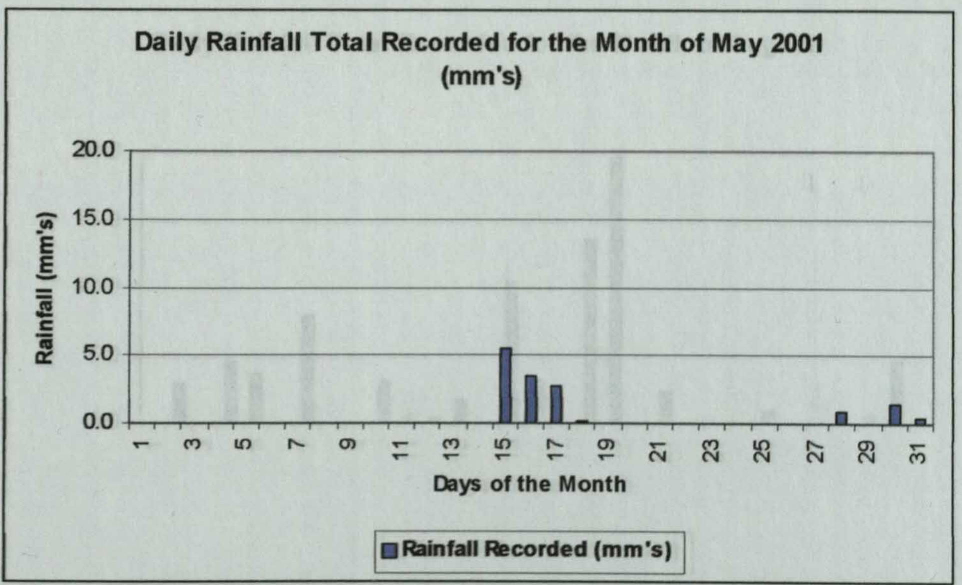


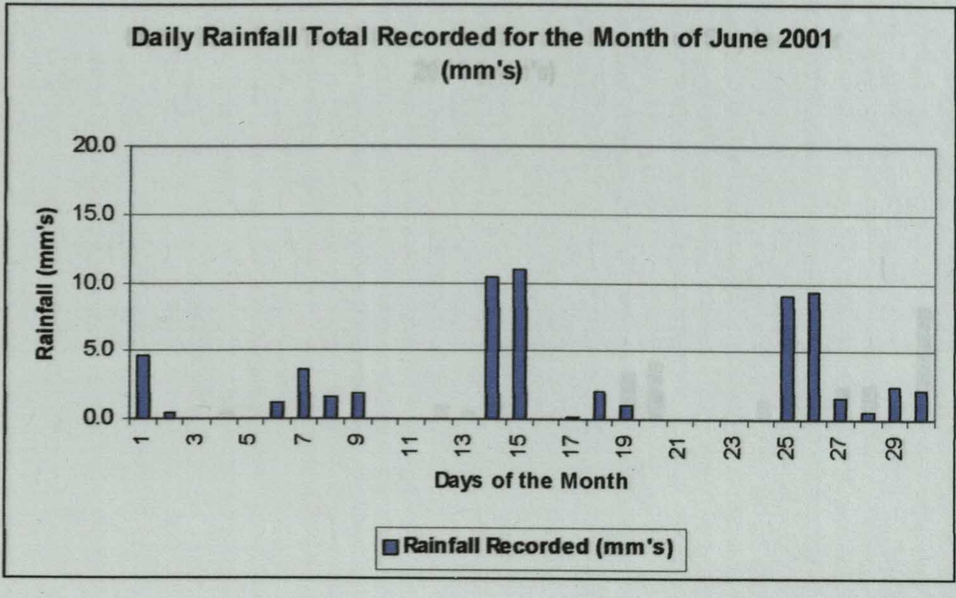




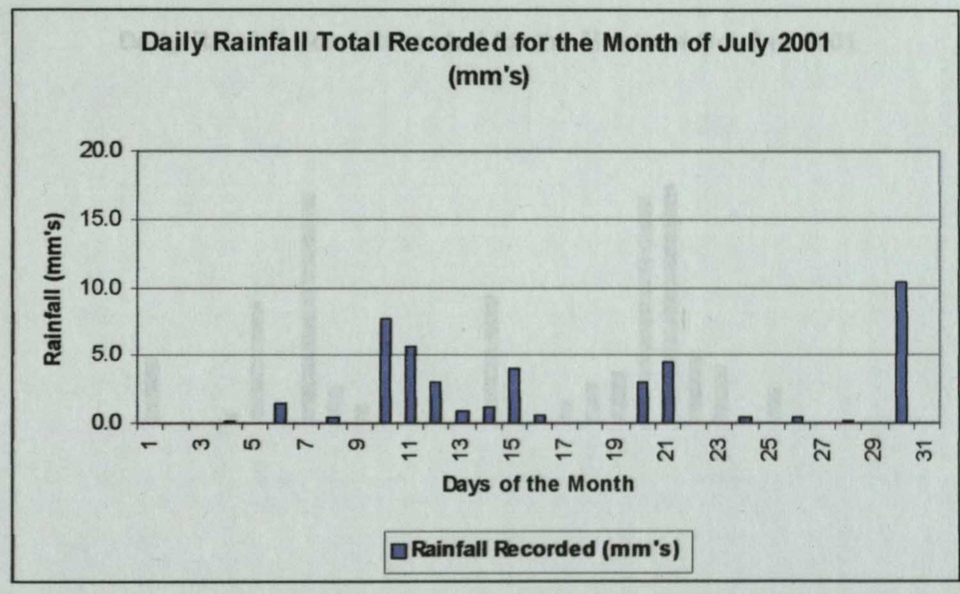
Appendix 2
Daily Rainfall Totals Recorded (mm's) for January 2001 – April 2003 Inclusive

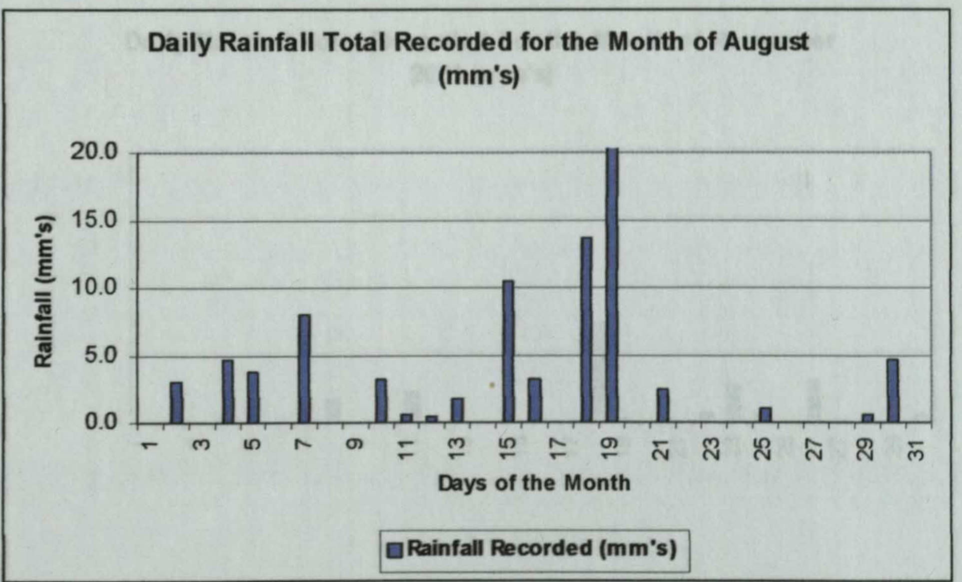


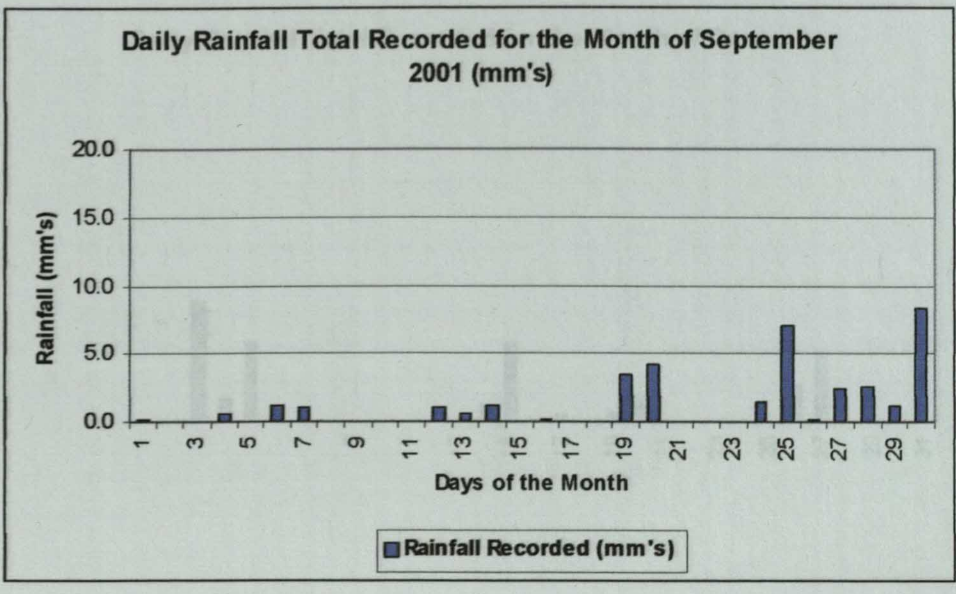




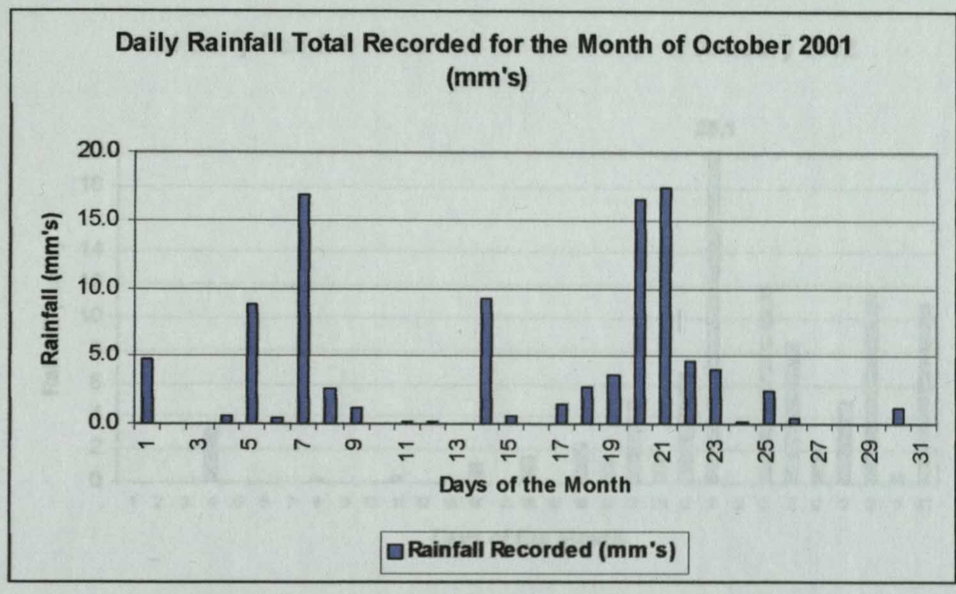
Appendix 2
Daily Rainfall Totals Recorded (mm's) for January 2001 – April 2003 Inclusive

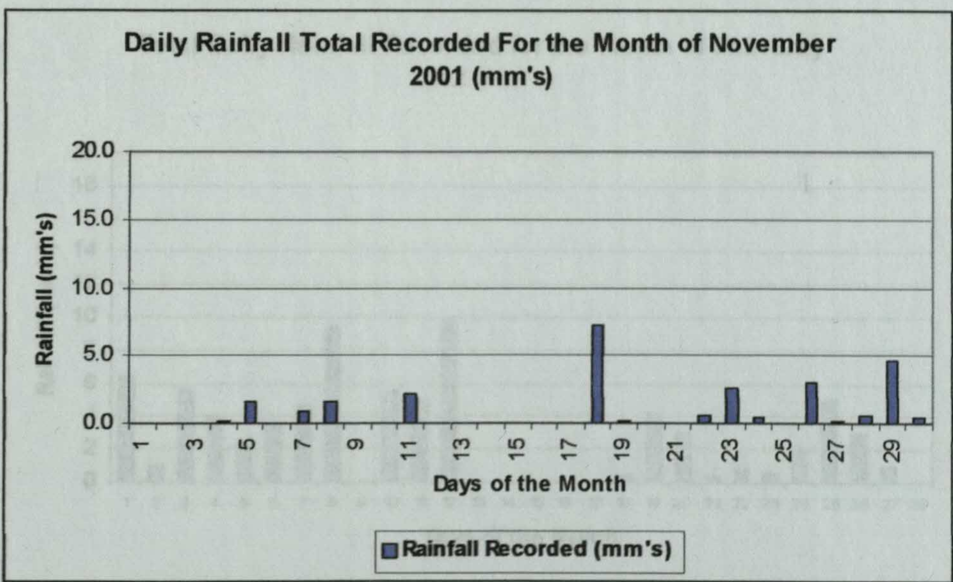


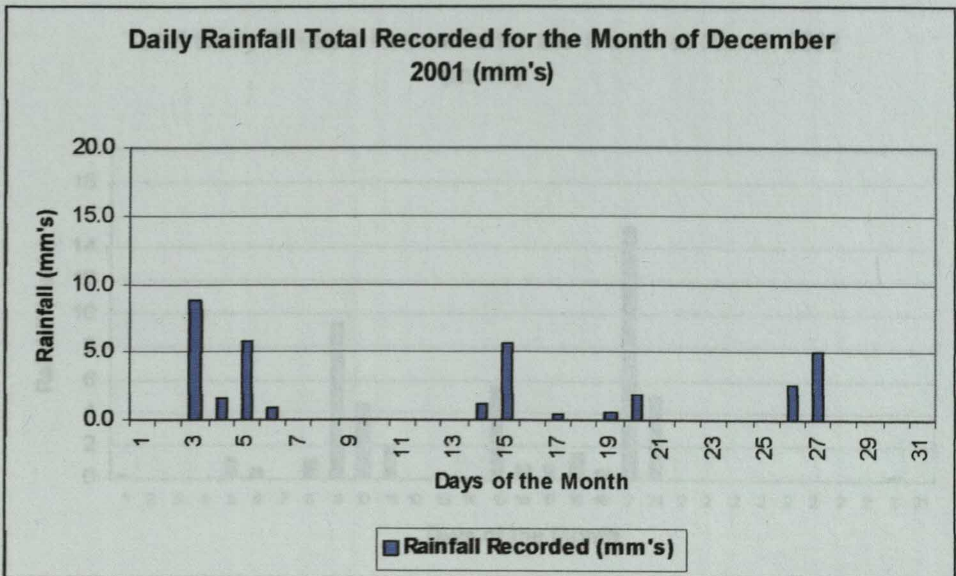




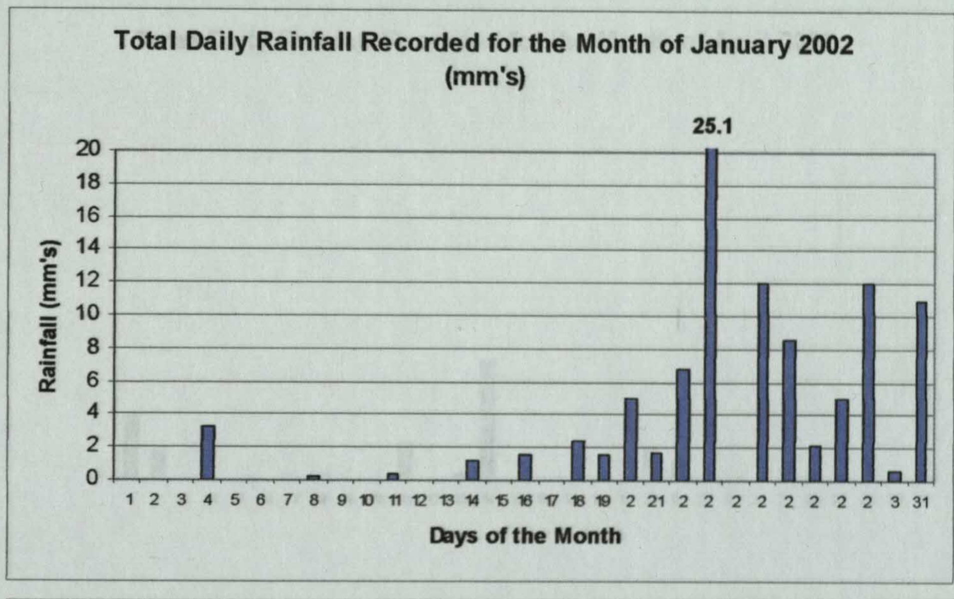
Appendix 2
Daily Rainfall Totals Recorded (mm's) for January 2001 – April 2003 Inclusive

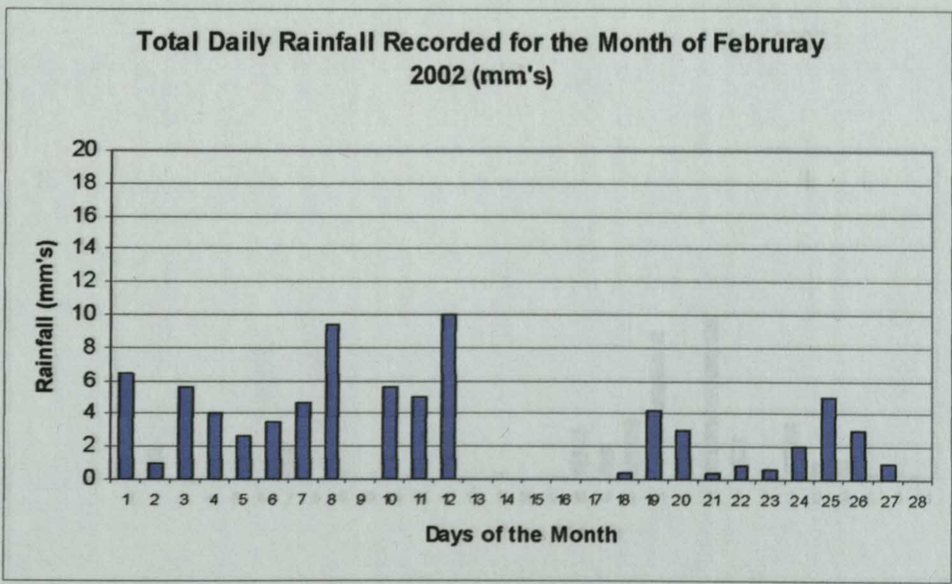


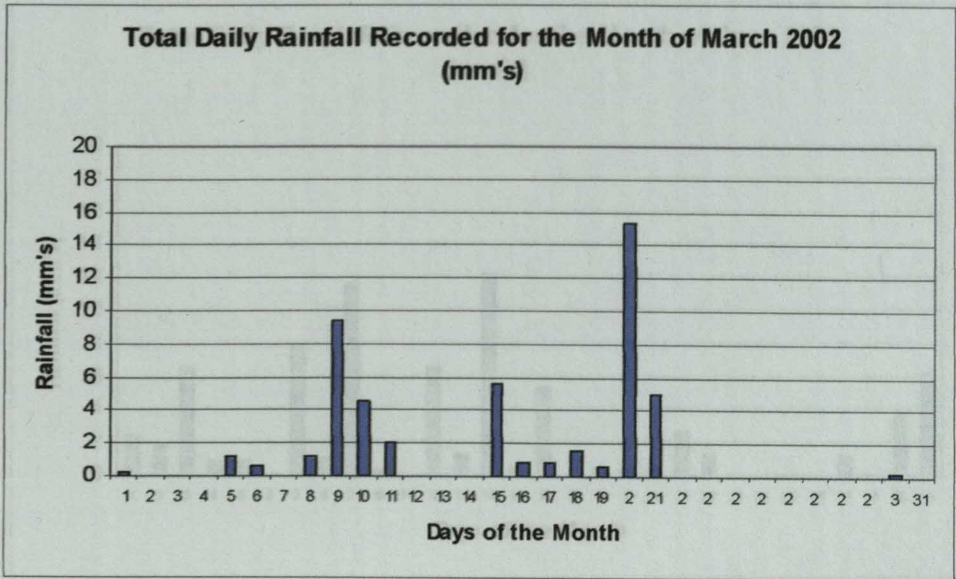




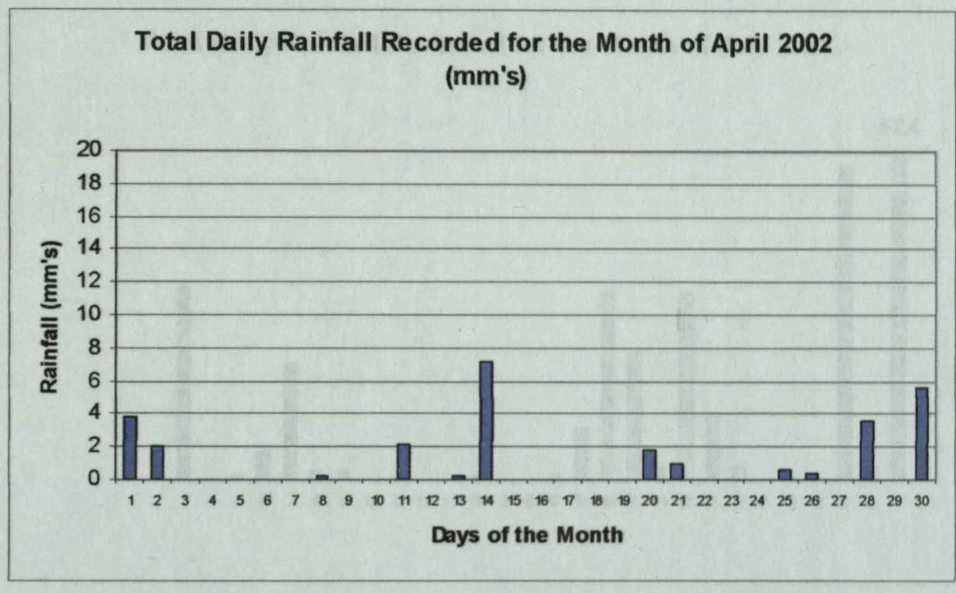
Appendix 2
Daily Rainfall Totals Recorded (mm's) for January 2001 – April 2003 Inclusive

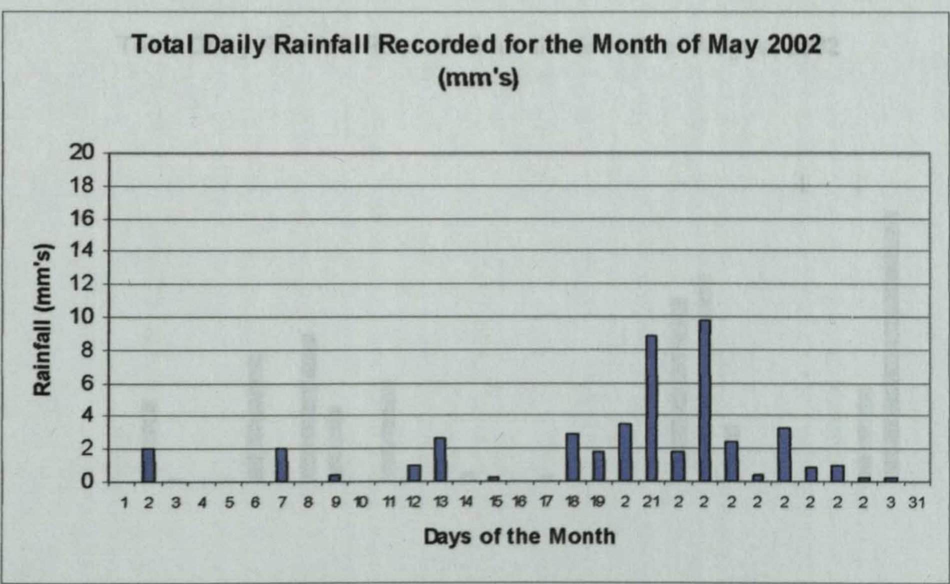


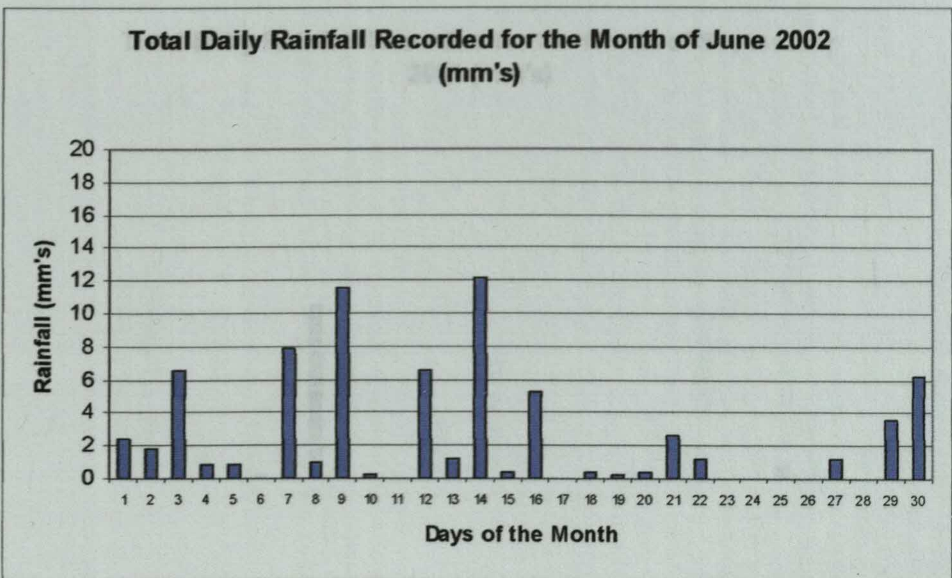




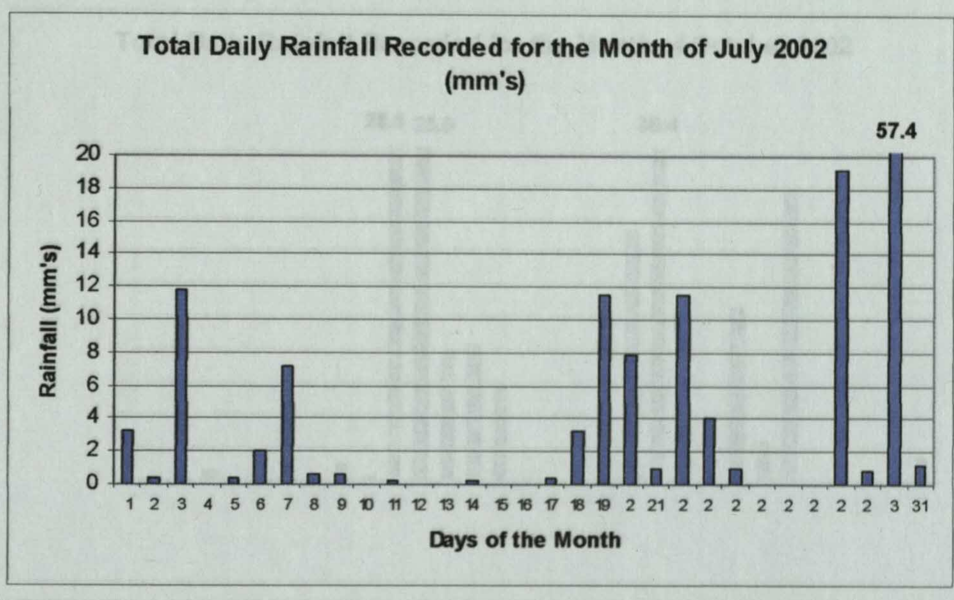
Appendix 2
Daily Rainfall Totals Recorded (mm's) for January 2001 – April 2003 Inclusive

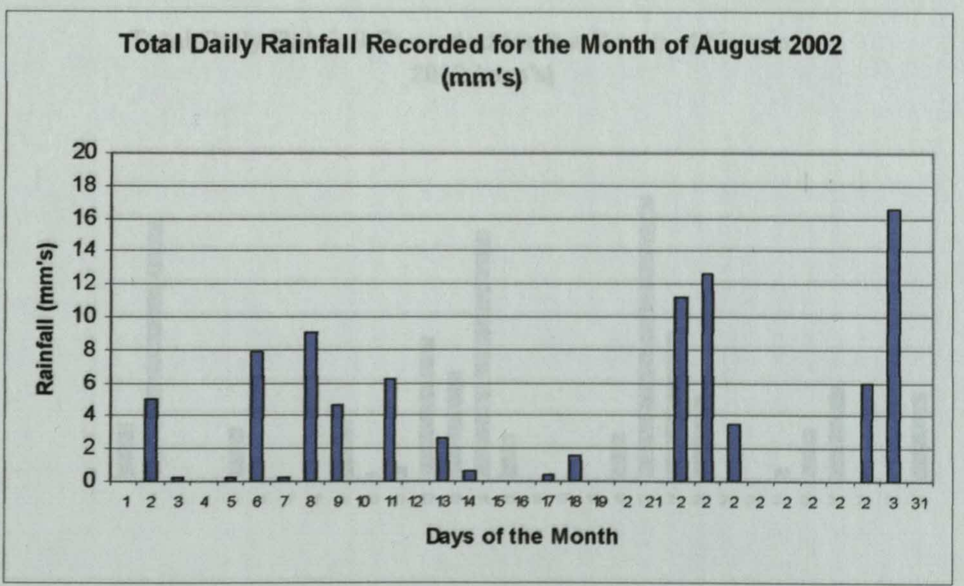


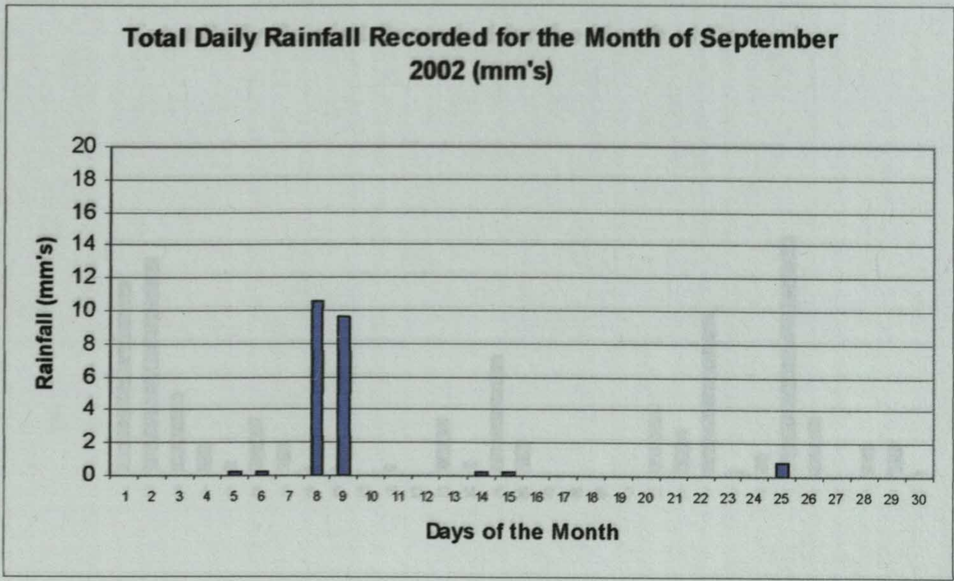




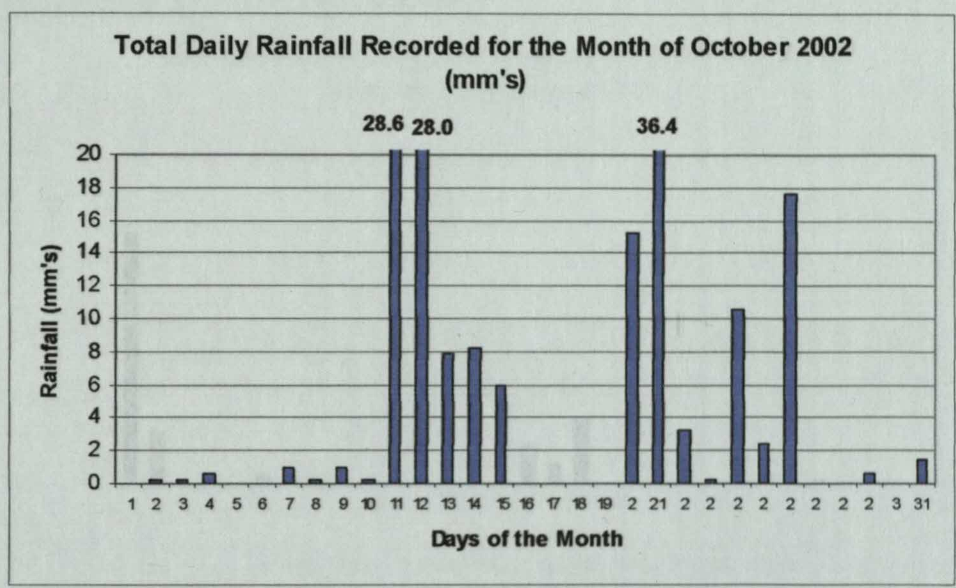
Appendix 2
Daily Rainfall Totals Recorded (mm's) for January 2001 – April 2003 Inclusive

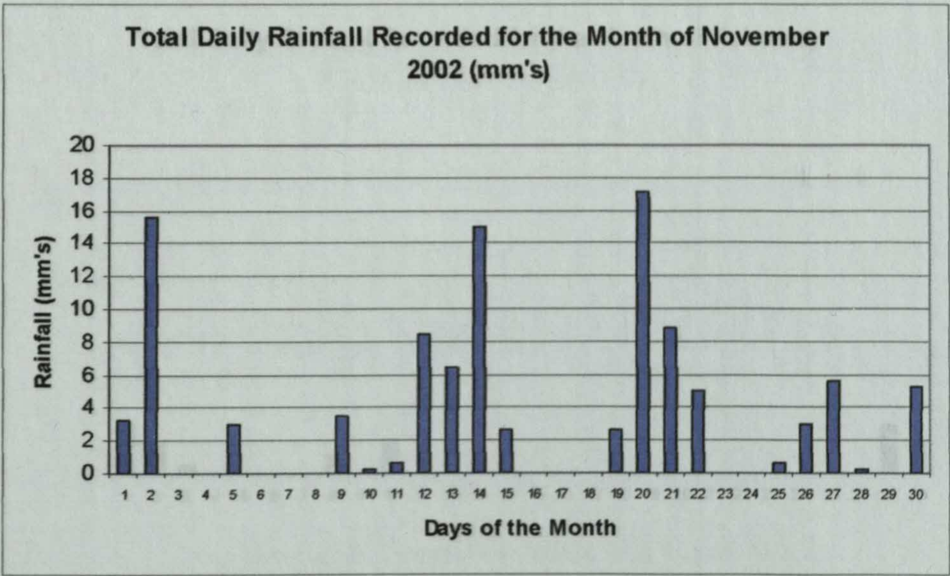


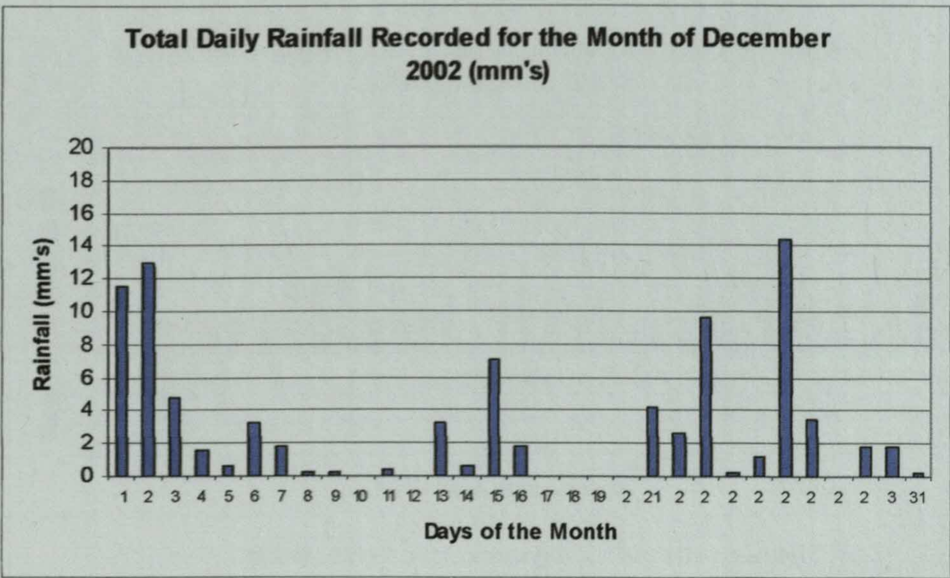




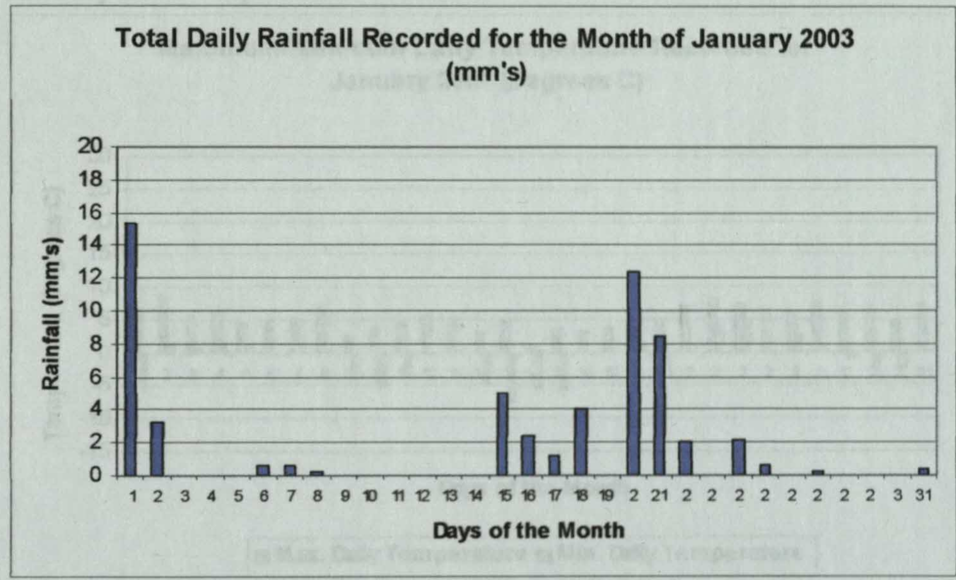
Appendix 2
Daily Rainfall Totals Recorded (mm's) for January 2001 – April 2003 Inclusive

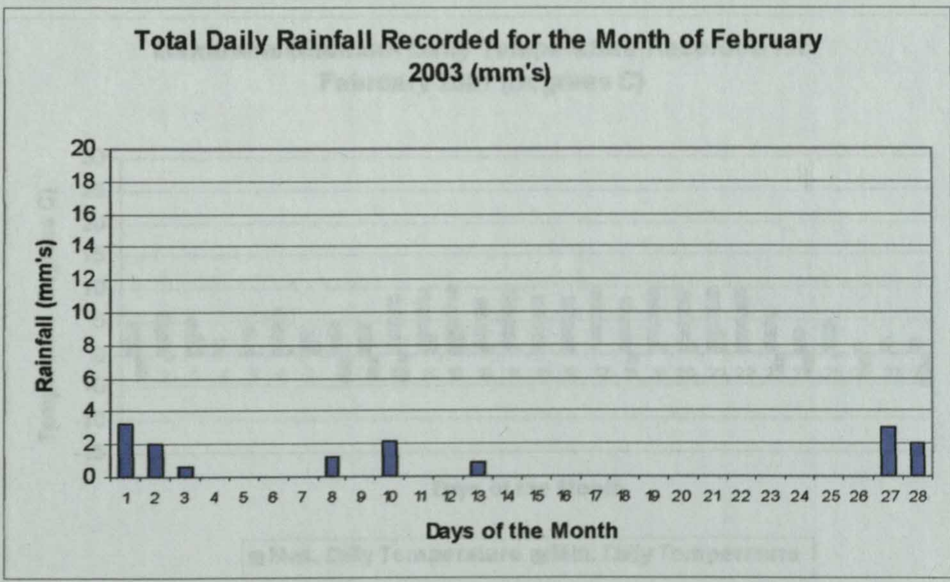




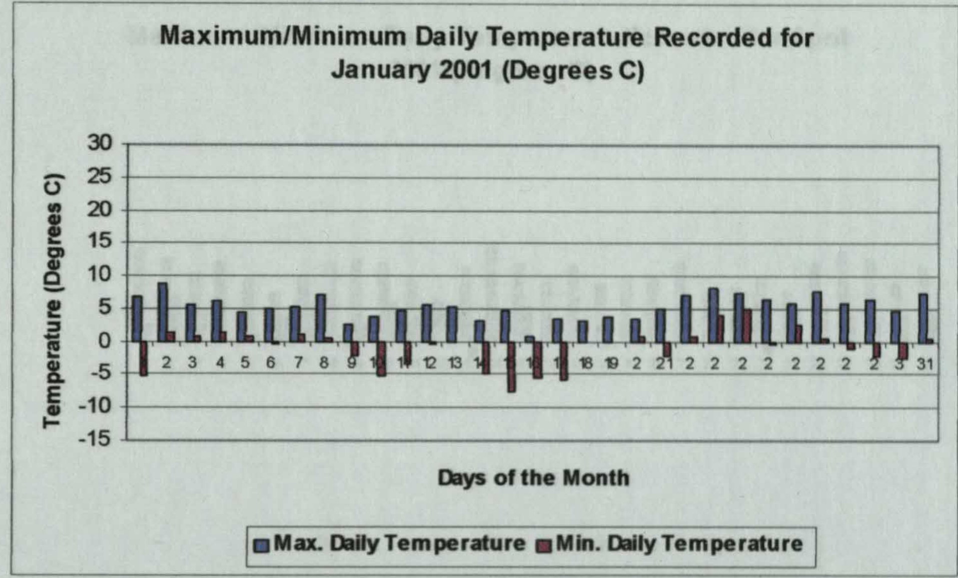


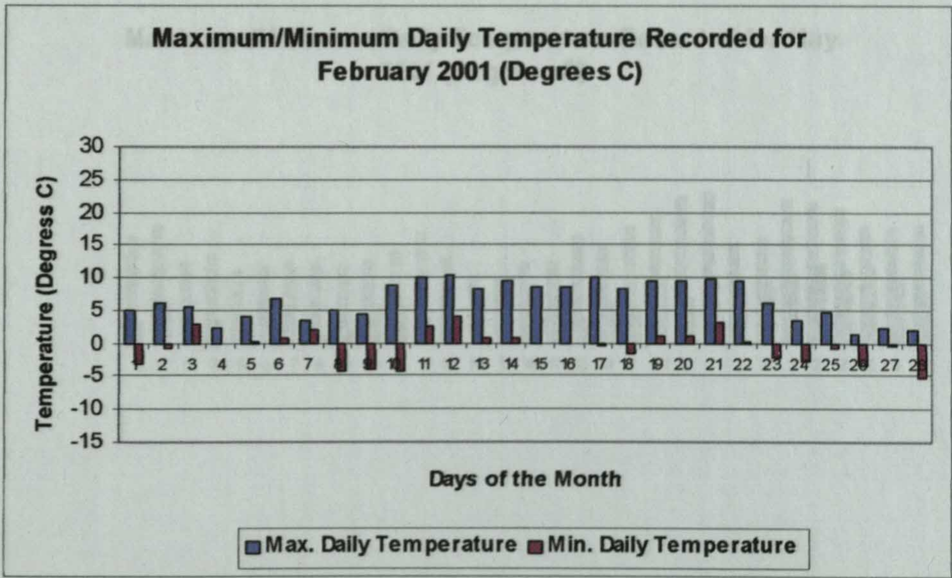
Appendix 2
Daily Rainfall Totals Recorded (mm's) for January 2001 – April 2003 Inclusive

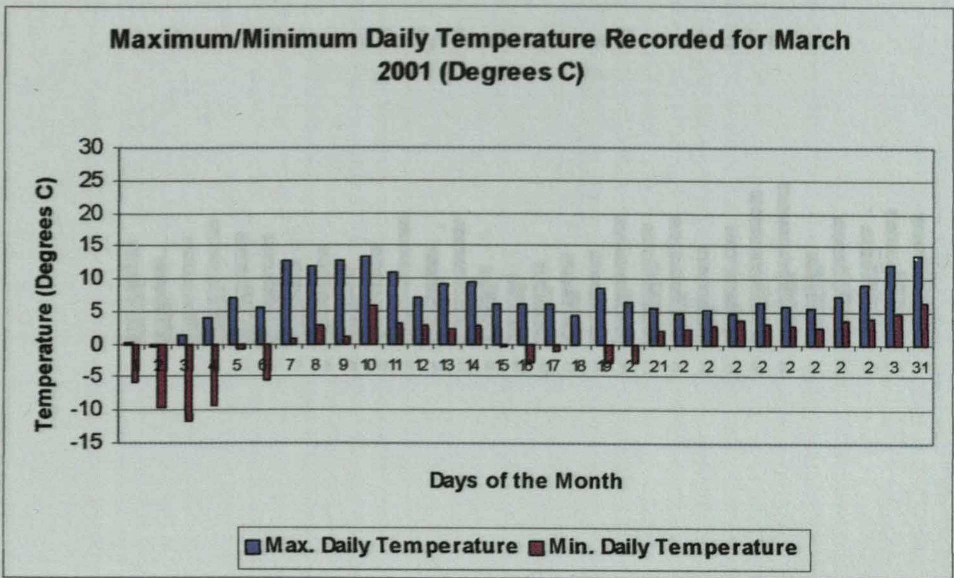




Appendix 2
Maximum and Minimum Daily Recorded Temperatures (Degrees C)
January 2001 – April 2003 Inclusive







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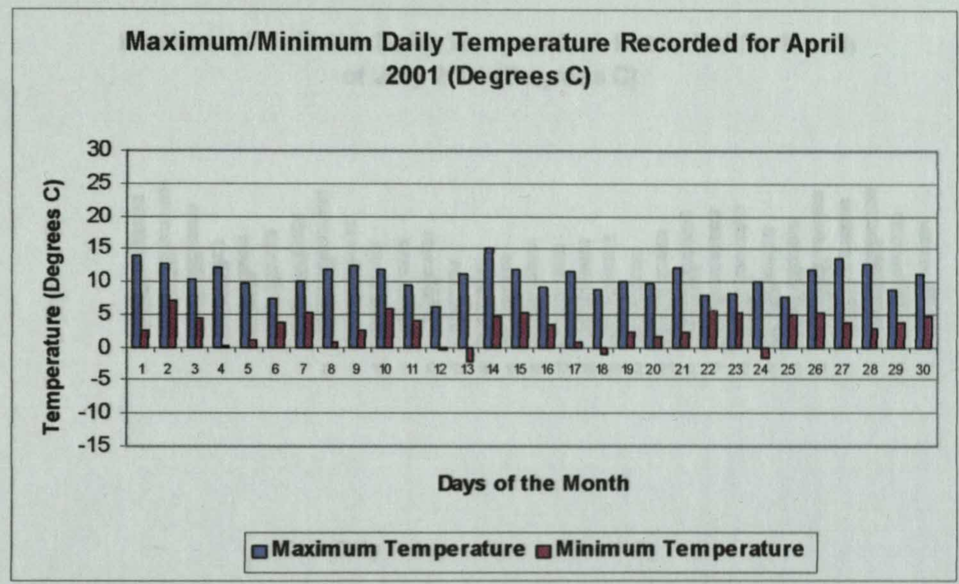
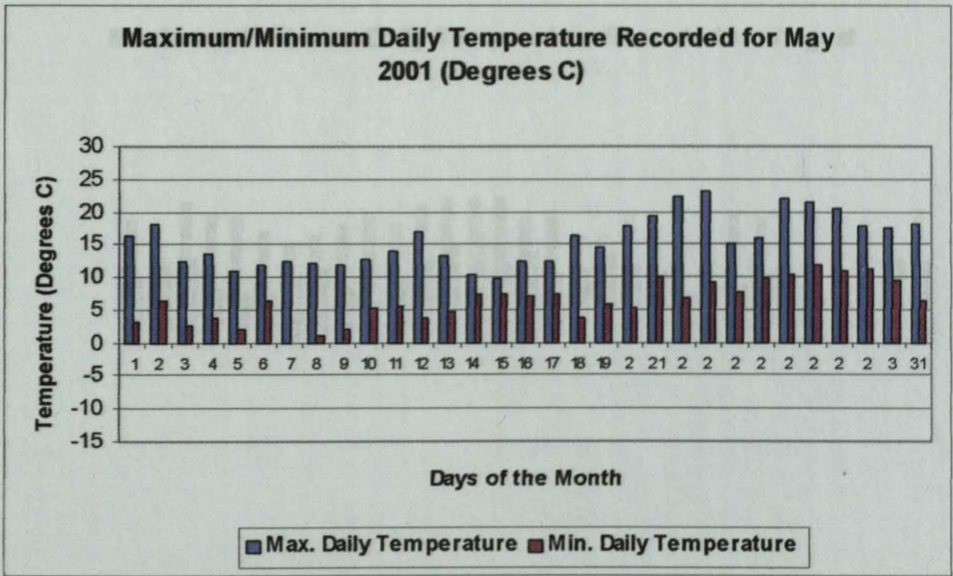
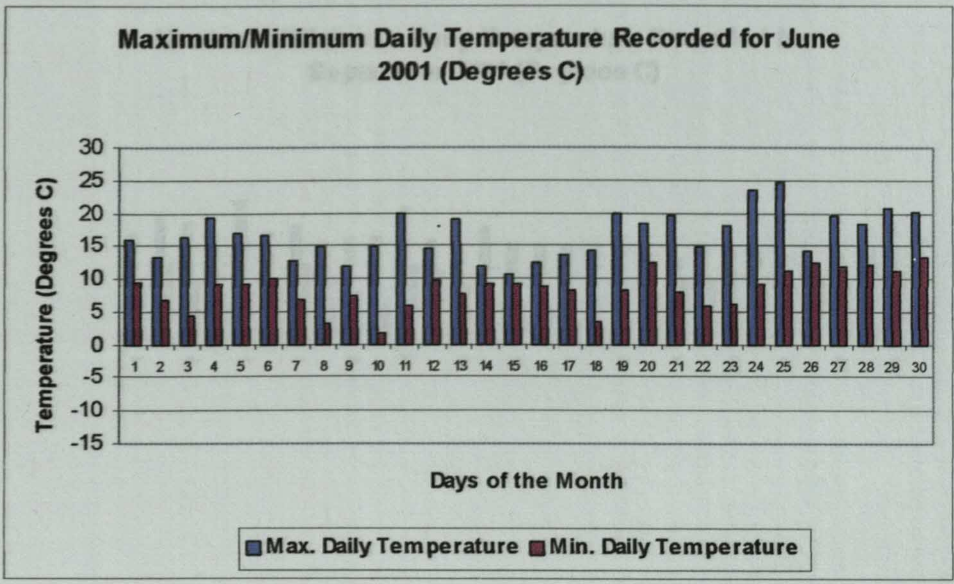
January 2001 – April 2003 Inclusive







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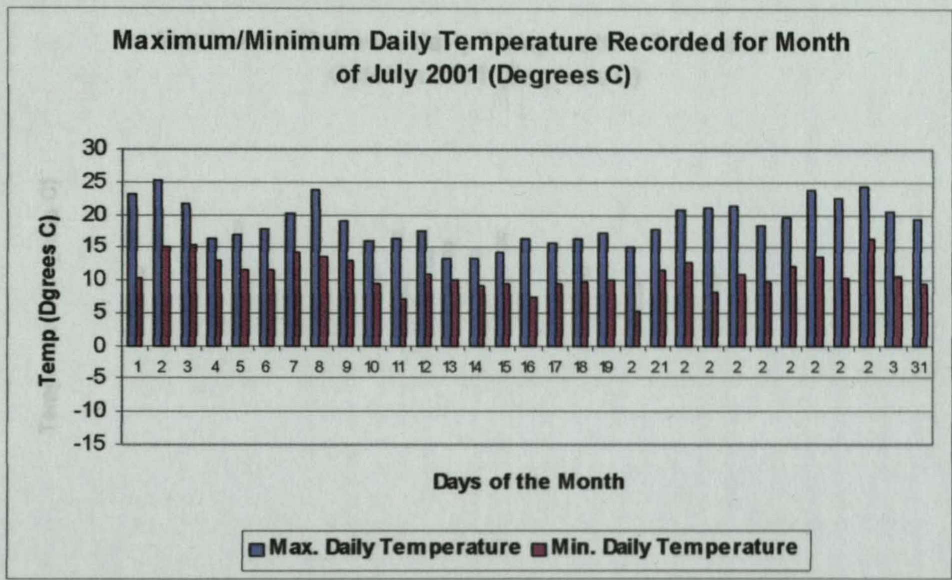
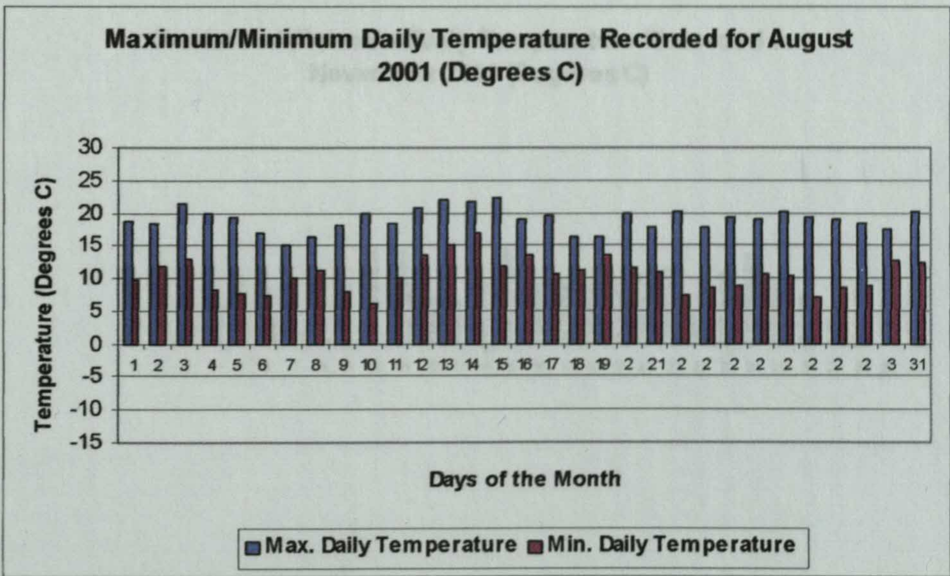
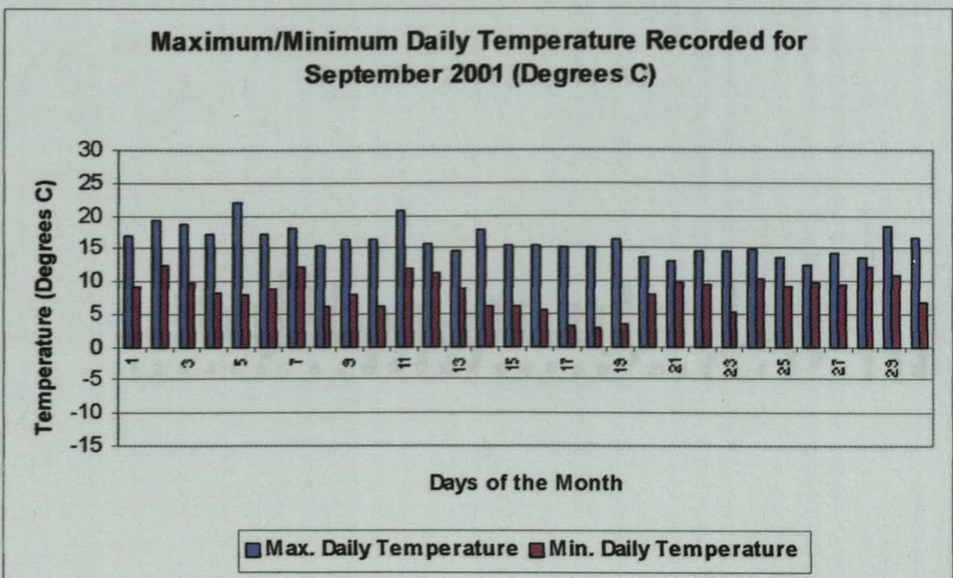
January 2001 – April 2003 Inclusive







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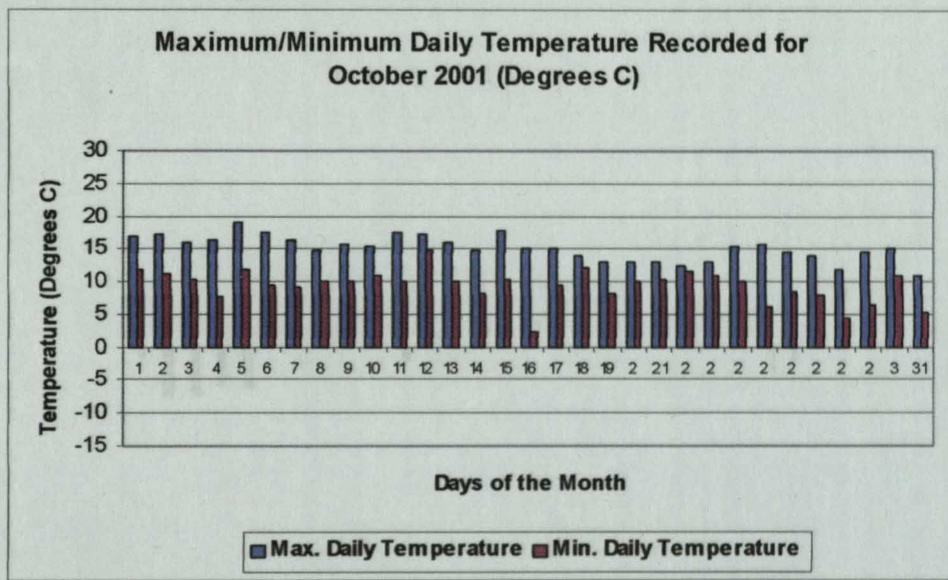
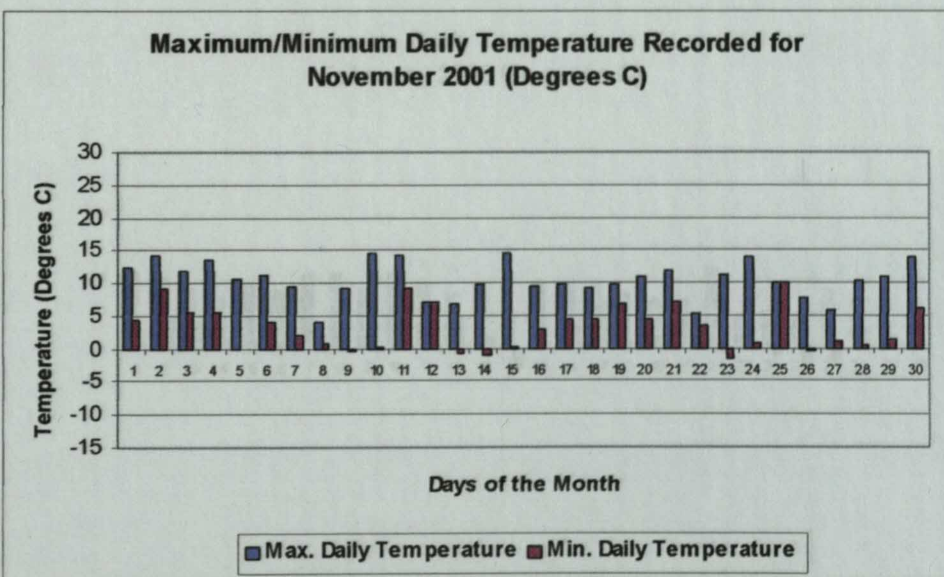
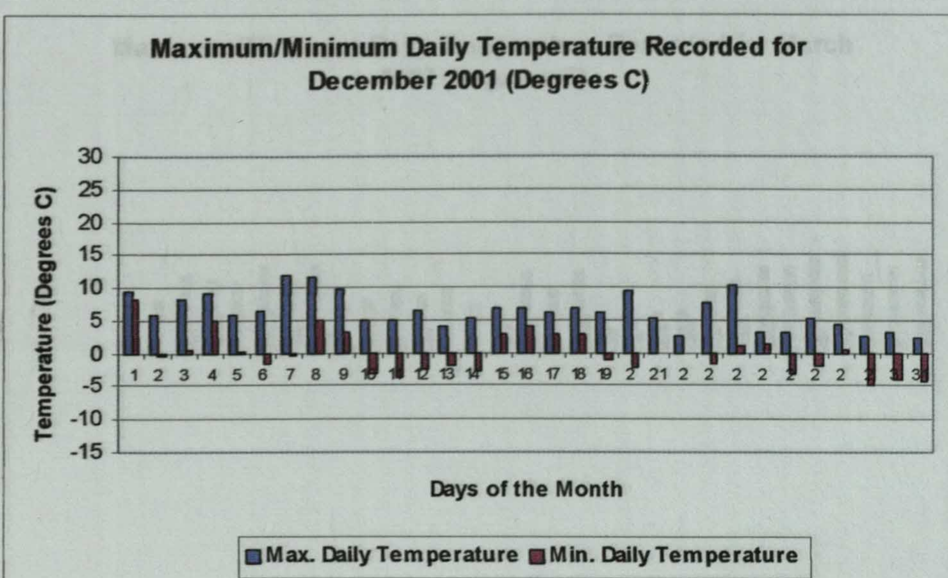
Maximum and Minimum Daily Recorded Temperatures (Degrees C)
January 2001 – April 2003 Inclusive







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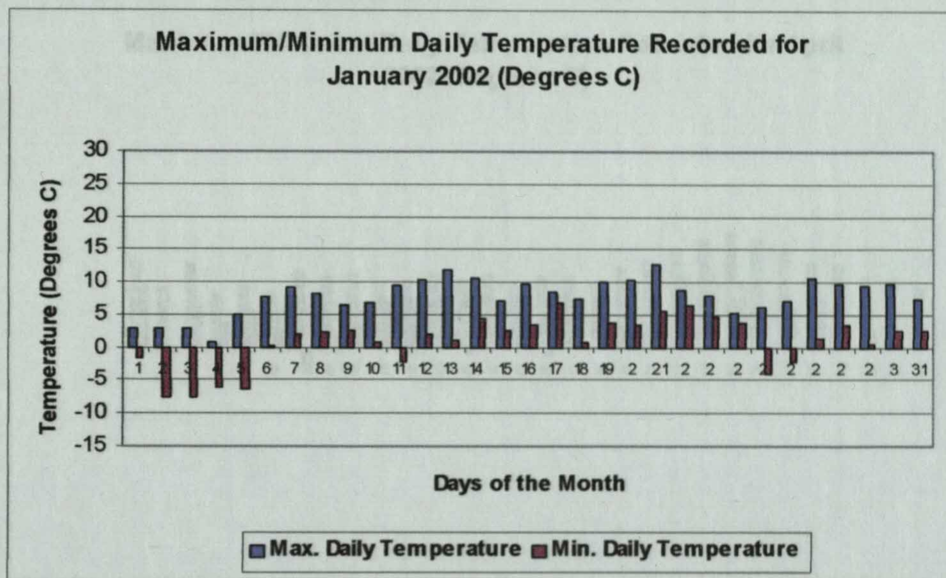
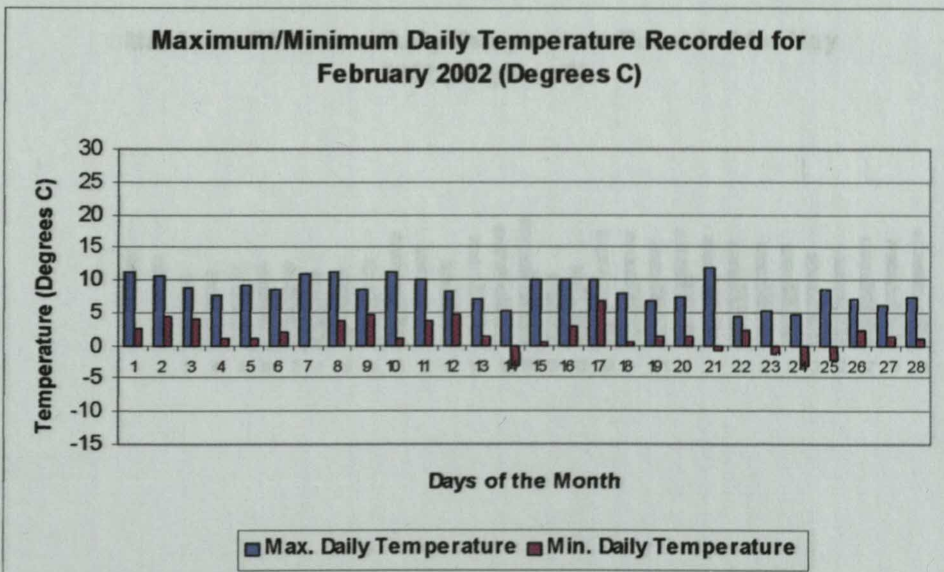
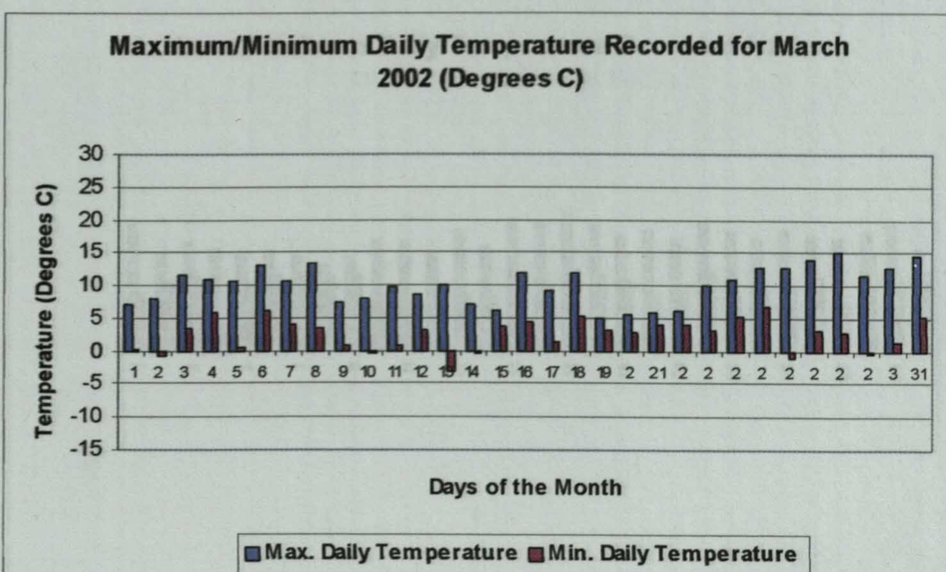
January 2001 – April 2003 Inclusive







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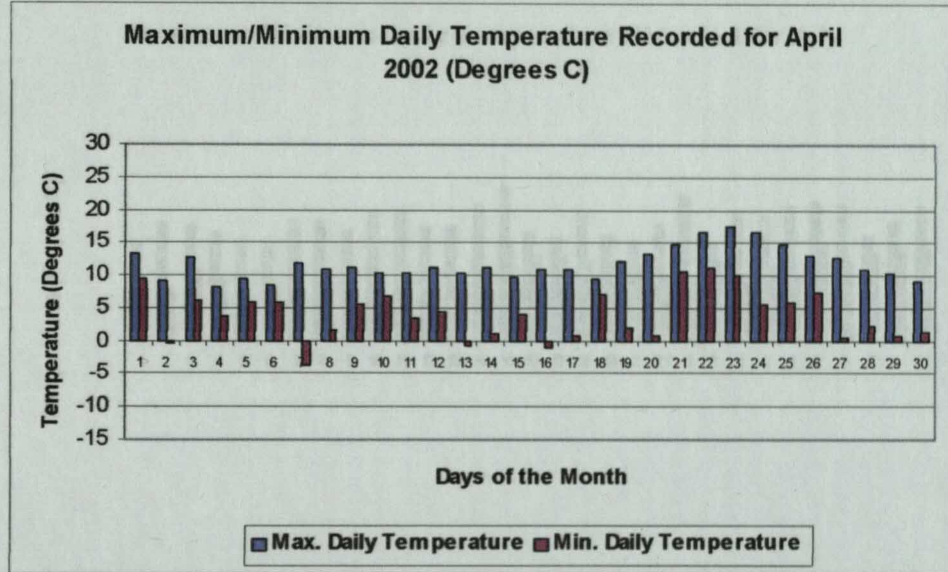
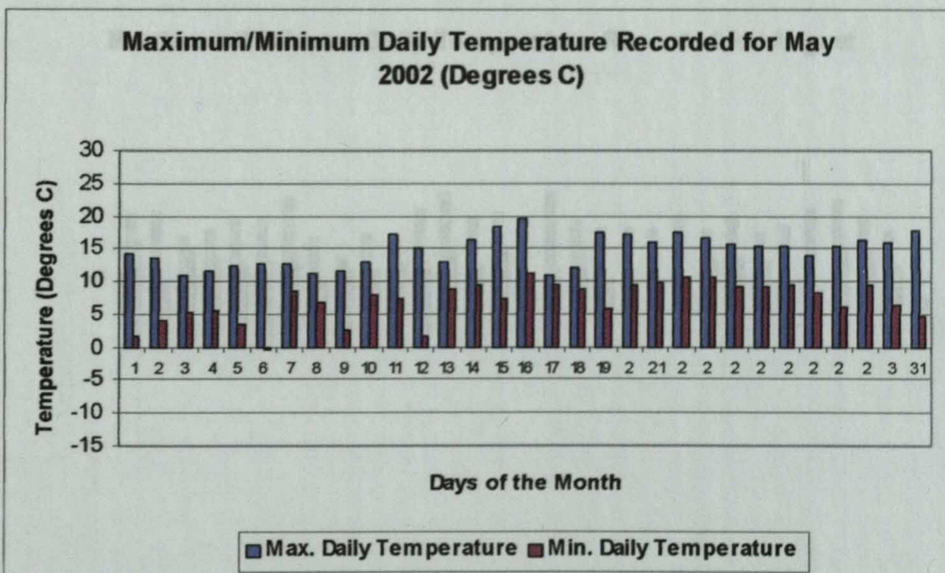
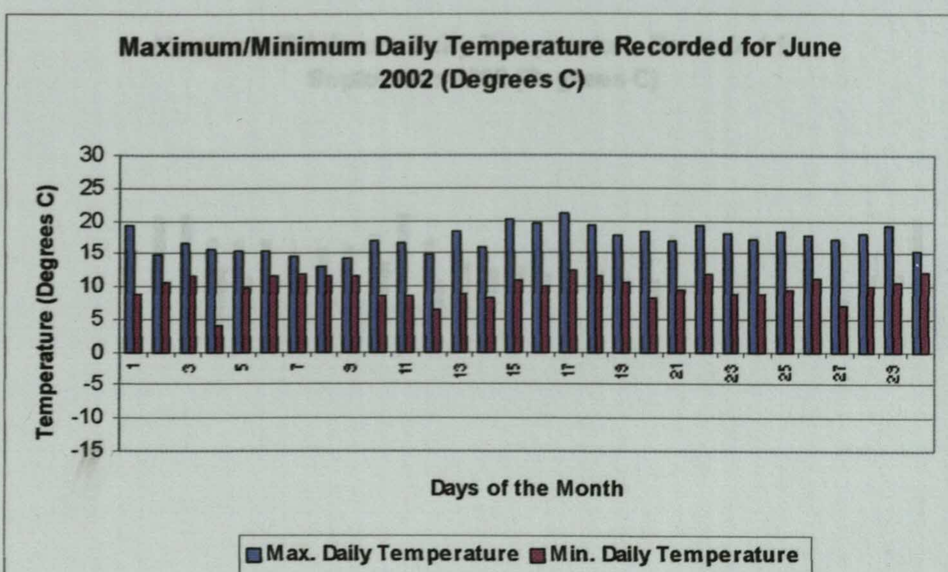
January 2001 – April 2003 Inclusive







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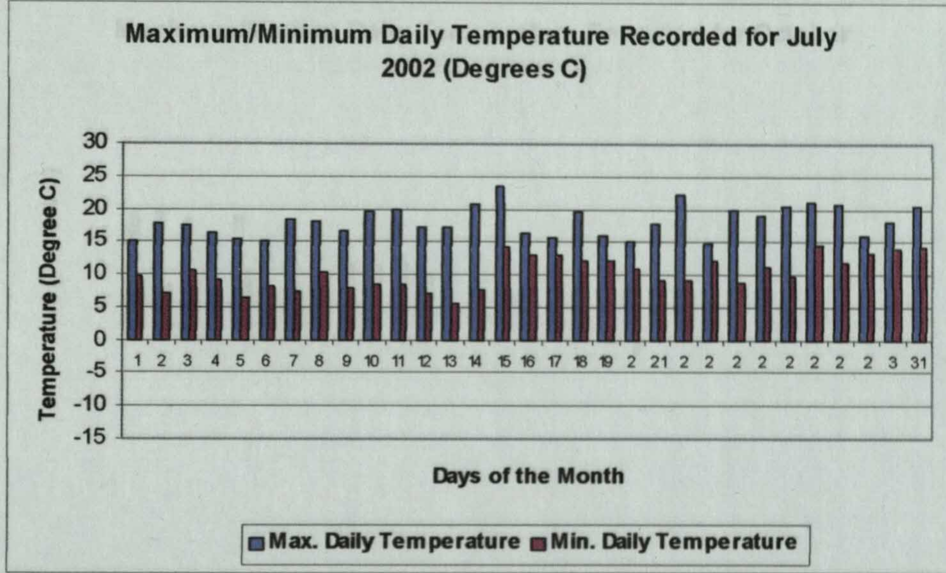
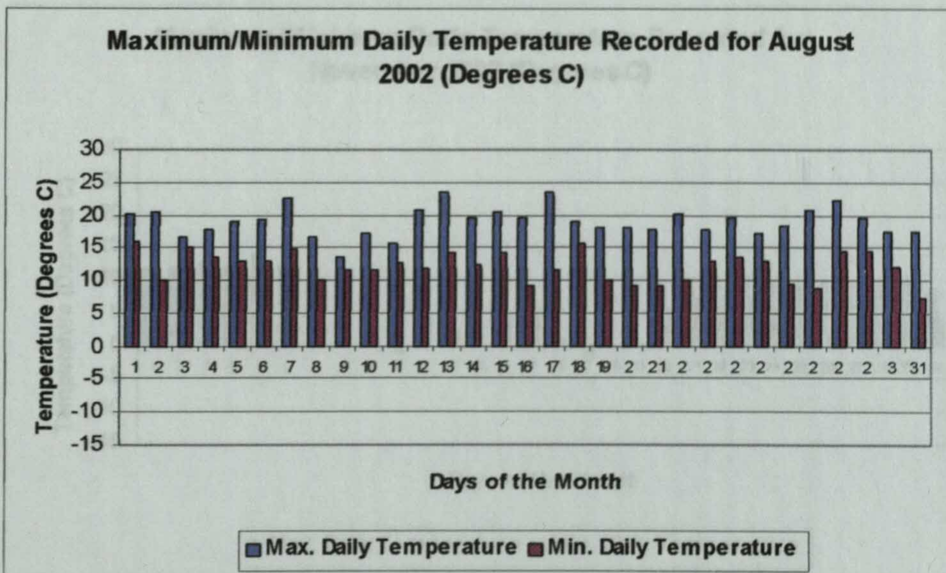
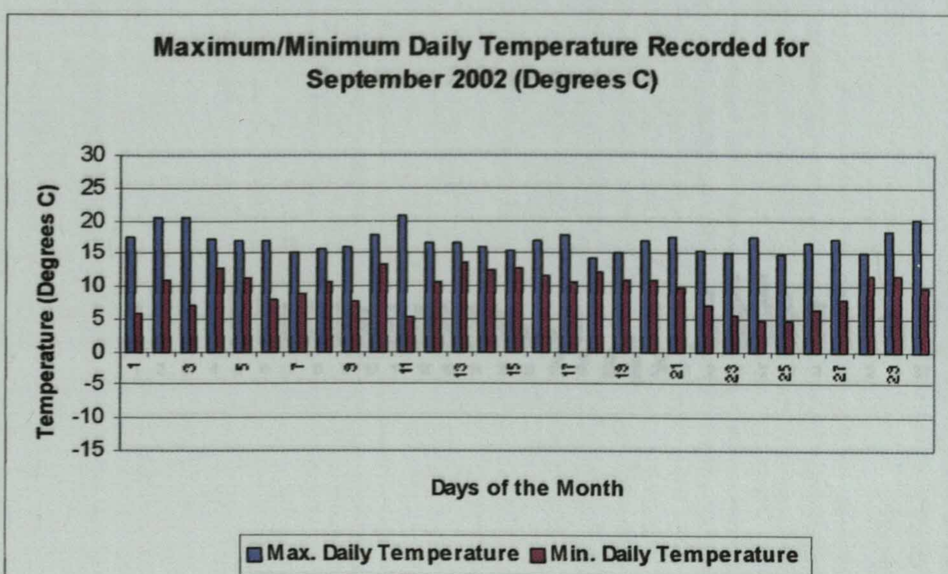
Maximum and Minimum Daily Recorded Temperatures (Degrees C)
January 2001 – April 2003 Inclusive







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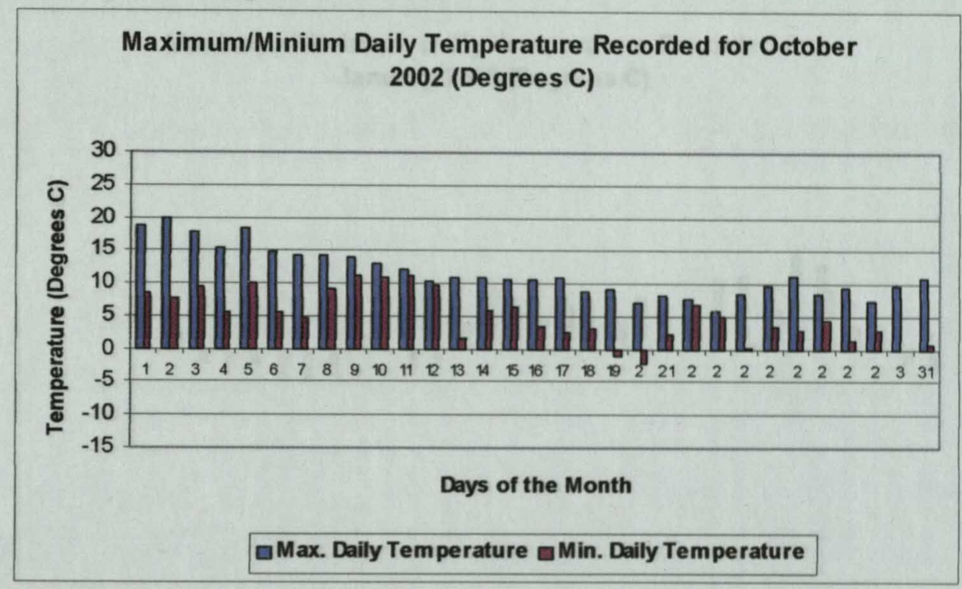
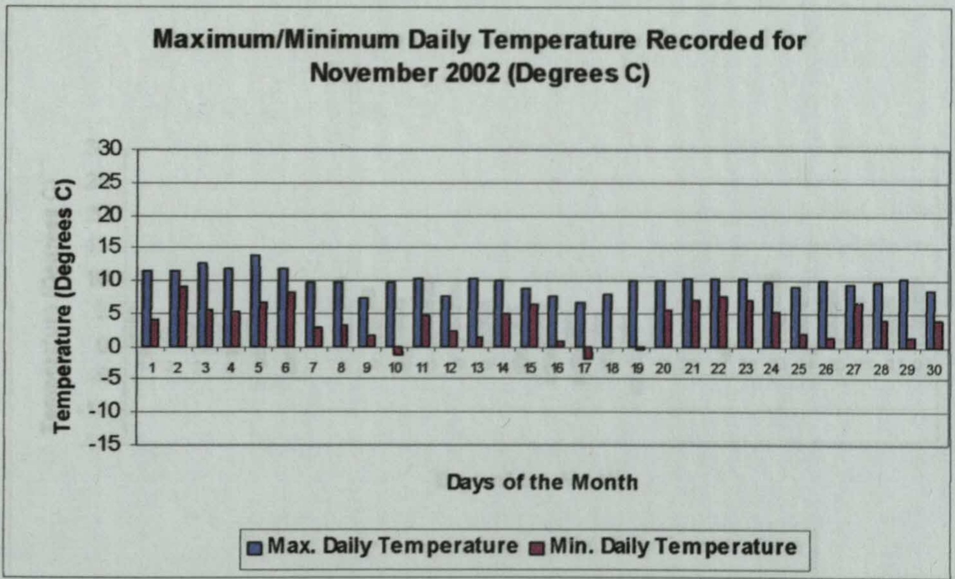
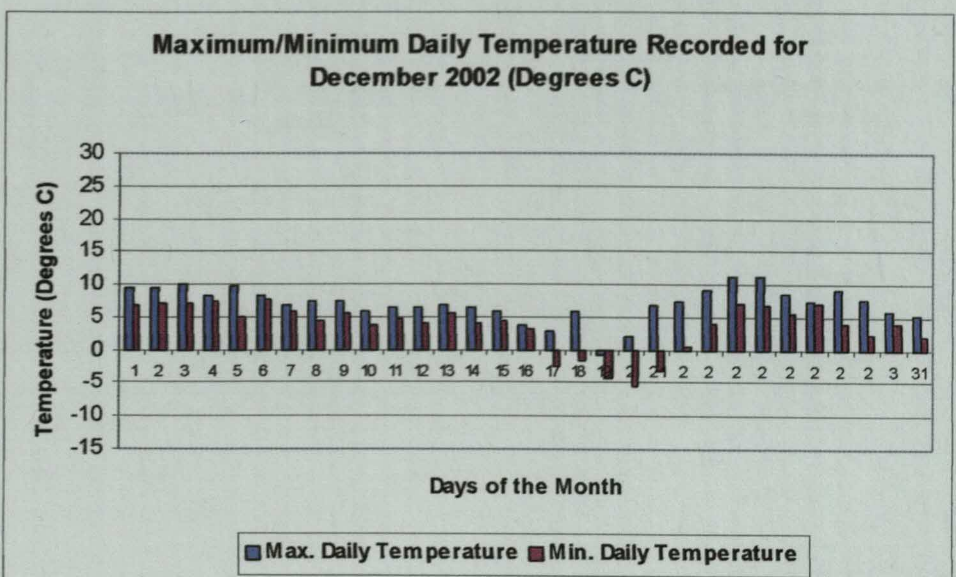
Maximum and Minimum Daily Recorded Temperatures (Degrees C)
January 2001 – April 2003 Inclusive







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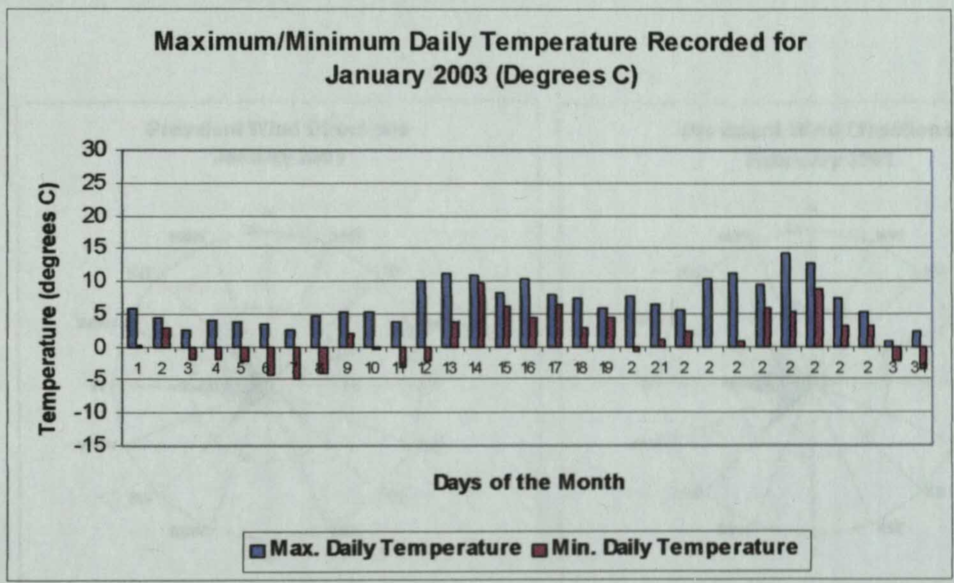
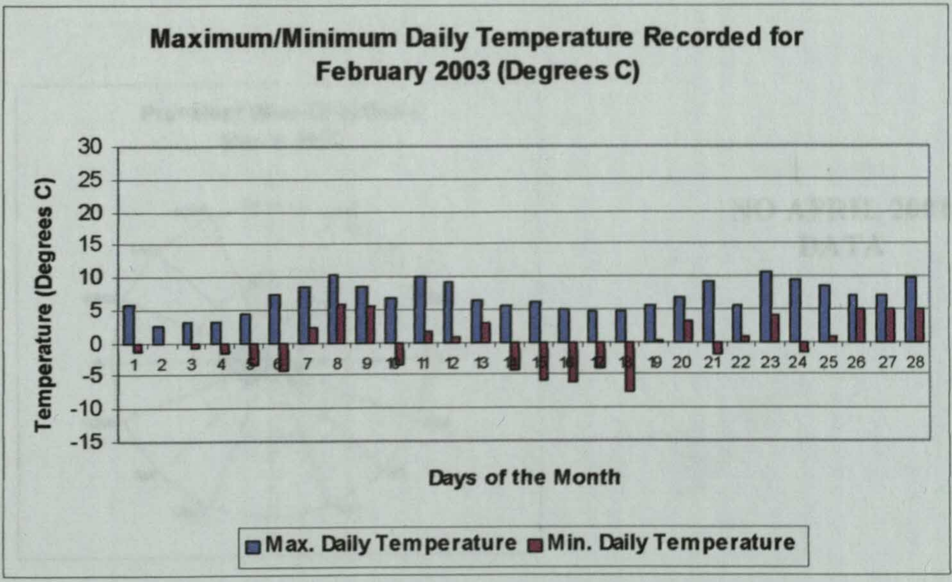
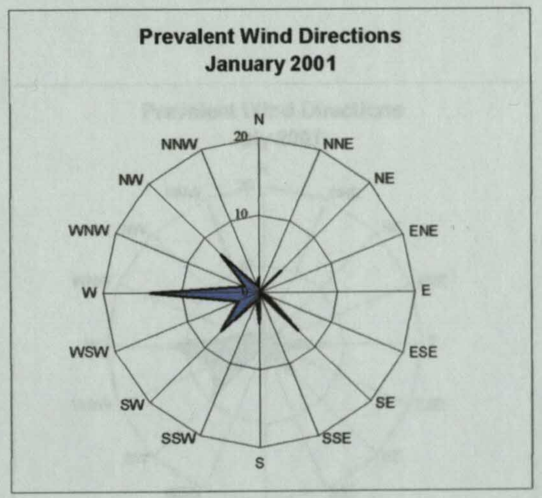
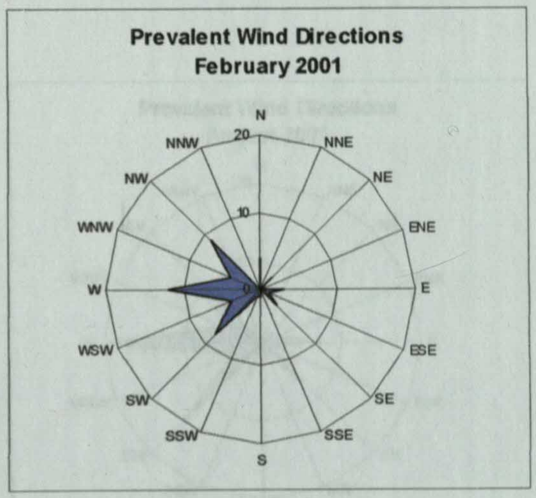
Maximum and Minimum Daily Recorded Temperatures (Degrees C)
January 2001 – April 2003 Inclusive

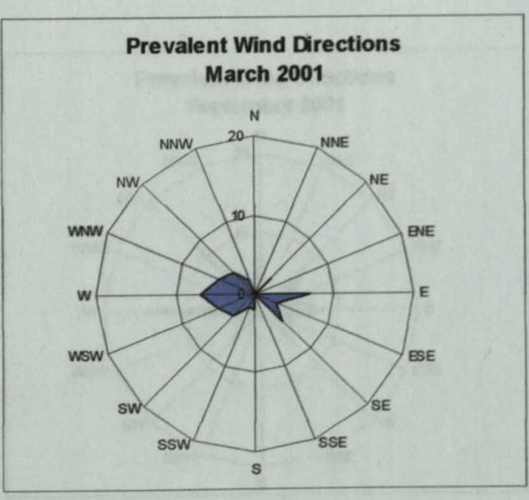




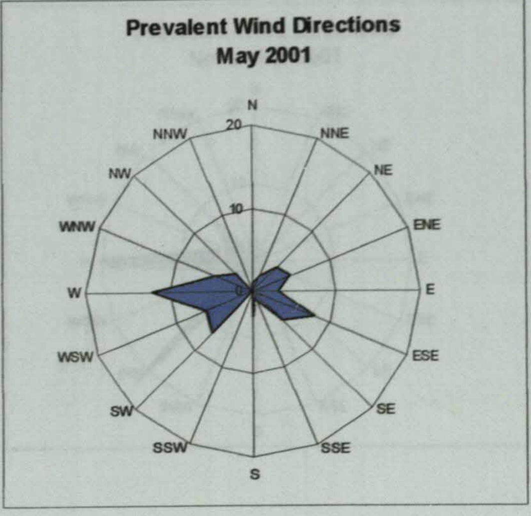
Appendix 2
Prevalent Wind Direction Recorded for January 2001 – April 2003 Inclusive

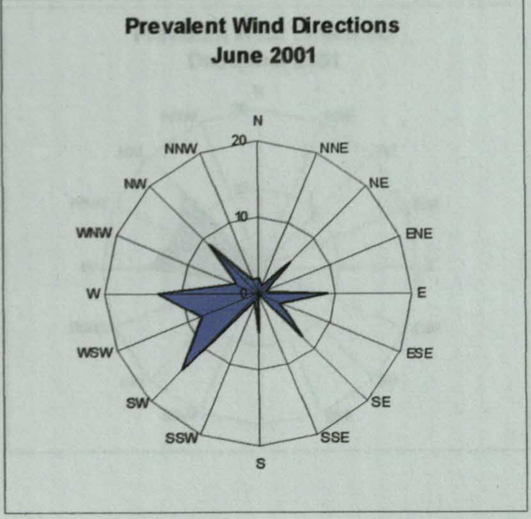




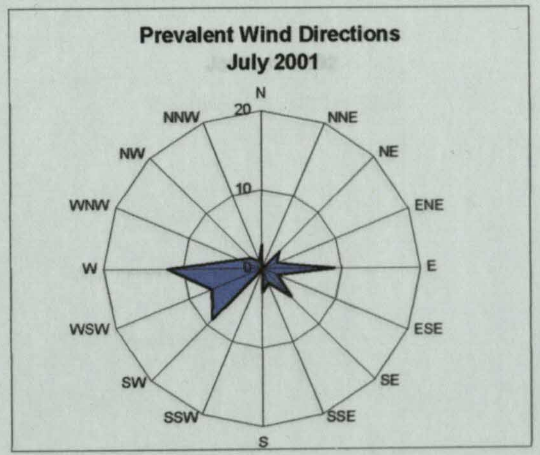


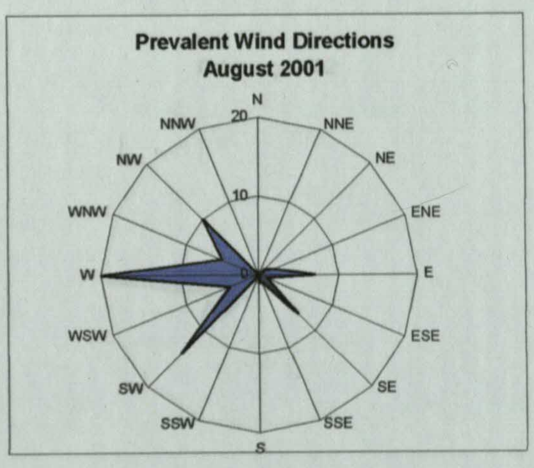
NO APRIL 2001 DATA

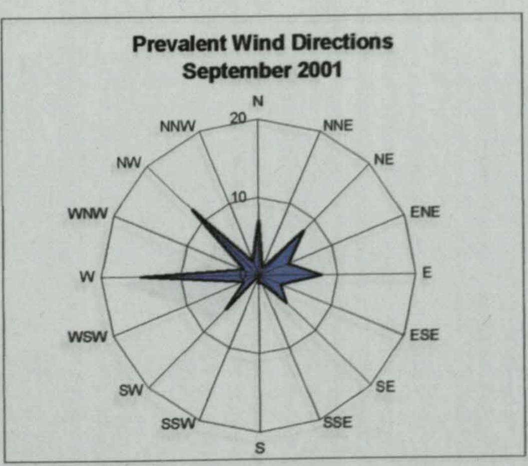


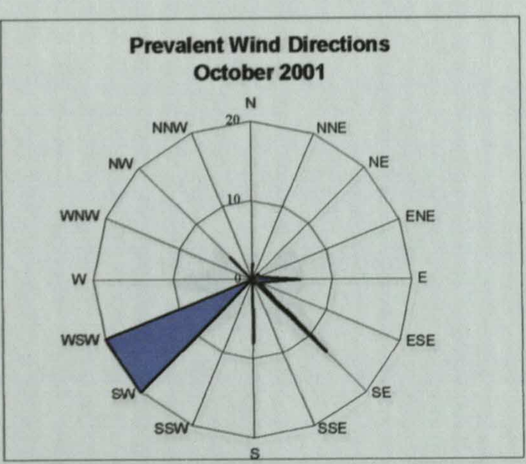


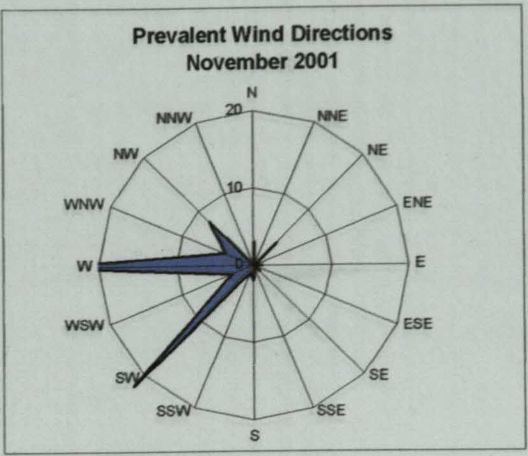
Appendix 2
Prevalent Wind Direction Recorded for January 2001 – April 2003 Inclusive

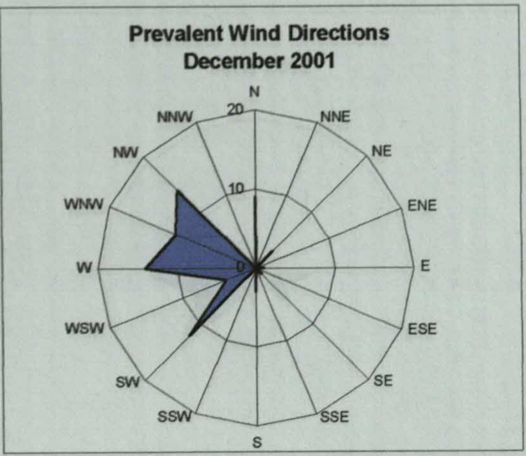




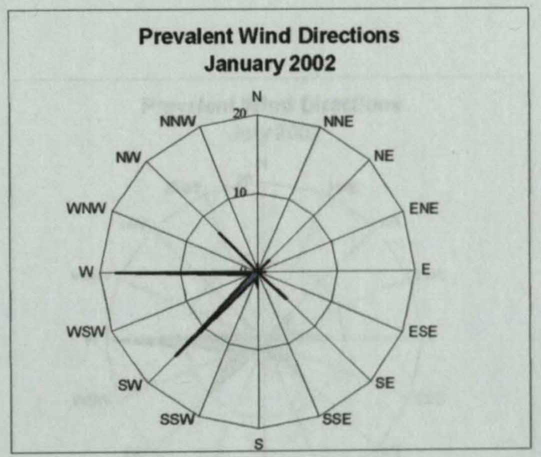


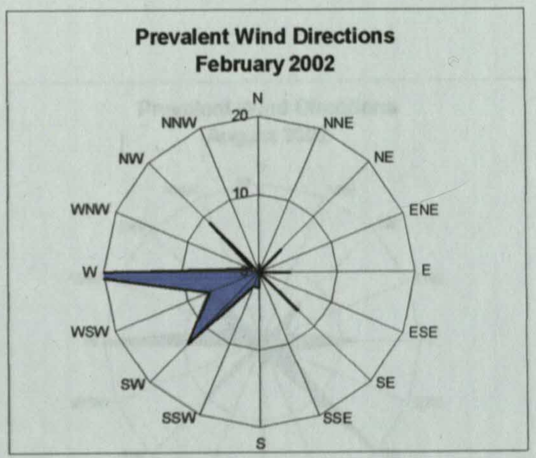


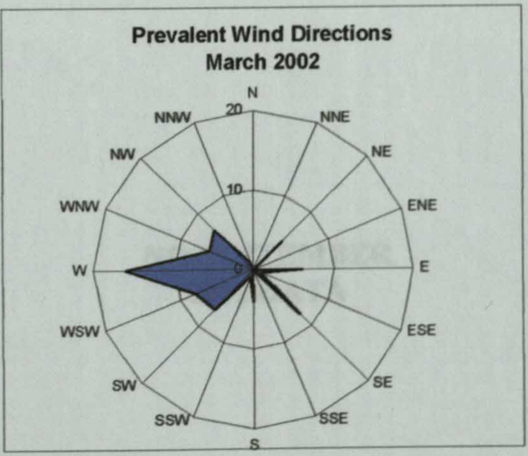


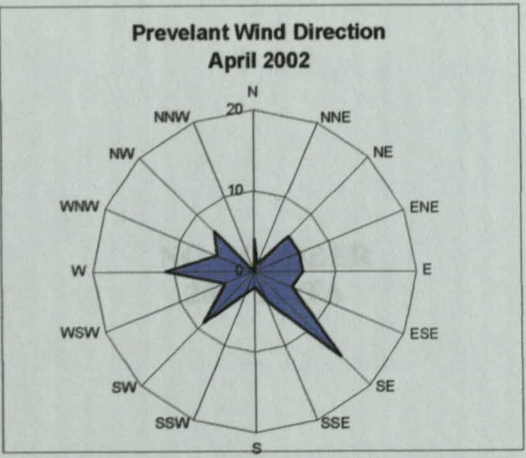


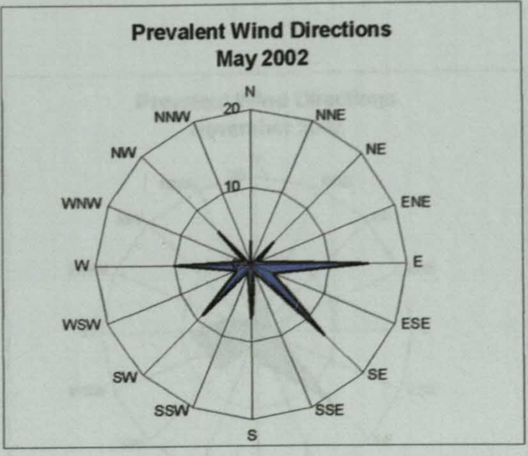
Appendix 2
Prevalent Wind Direction Recorded for January 2001 – April 2003 Inclusive

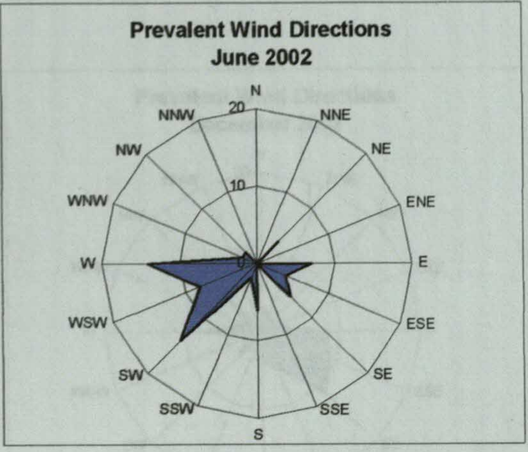




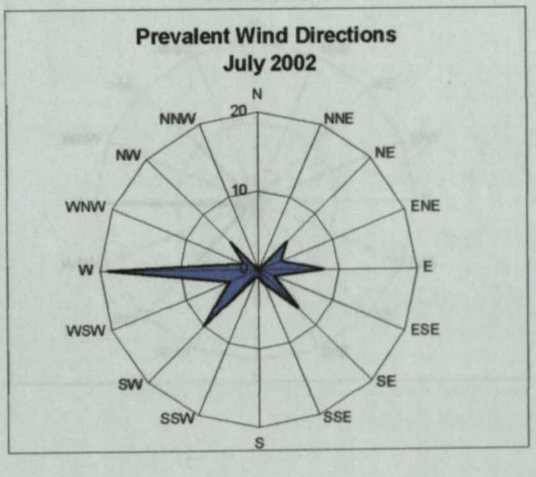


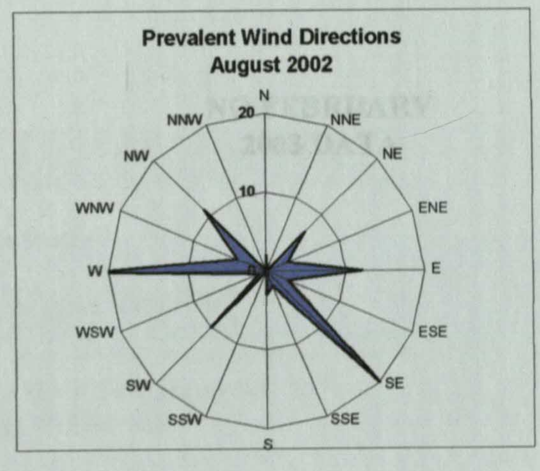






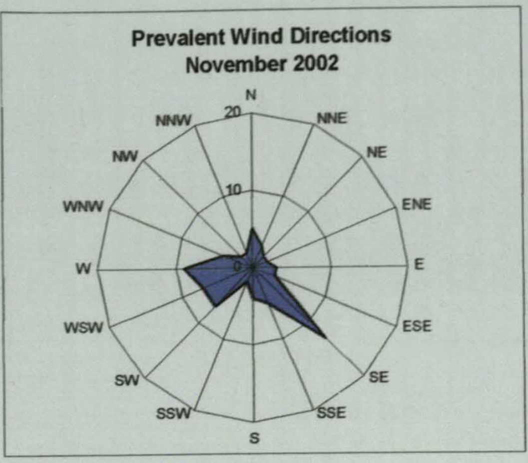
Appendix 2
Prevalent Wind Direction Recorded for January 2001 – April 2003 Inclusive

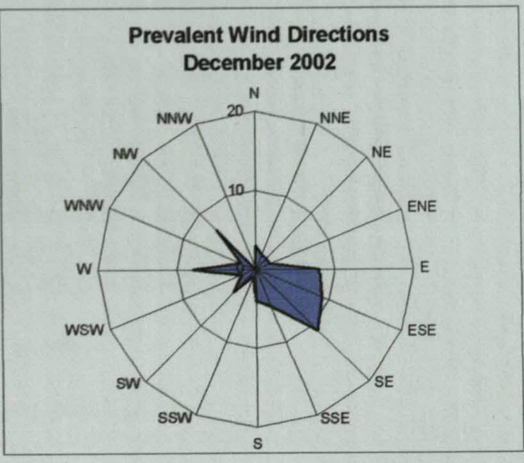




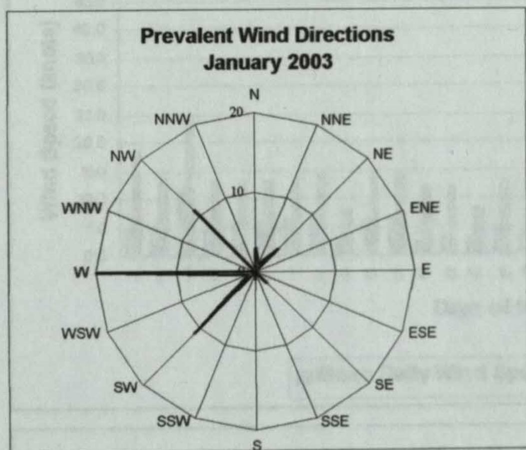
NO SEPTEMBER 2002 DATA

NO OCTOBER 2002 DATA





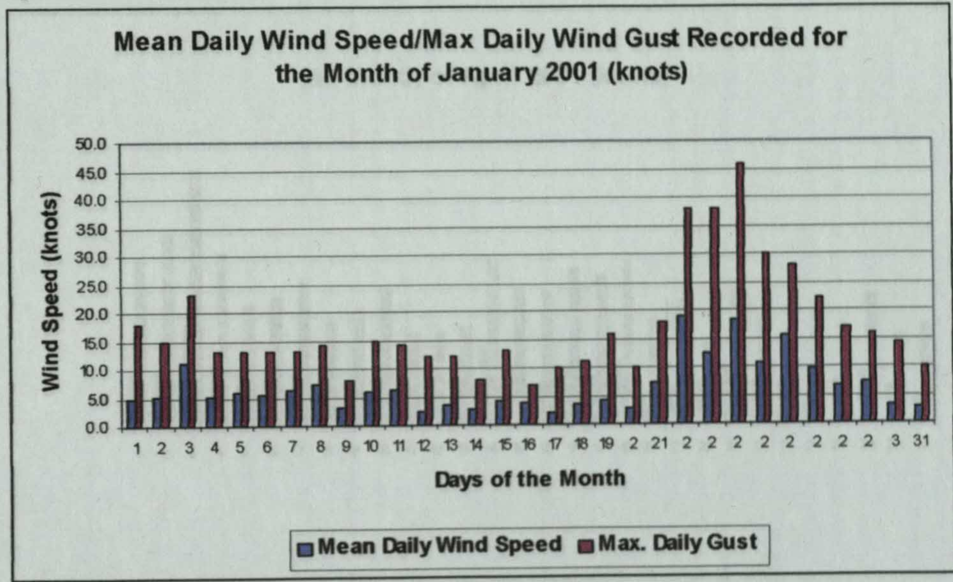
Appendix 2
Prevalent Wind Direction Recorded for January 2001 – April 2003 Inclusive

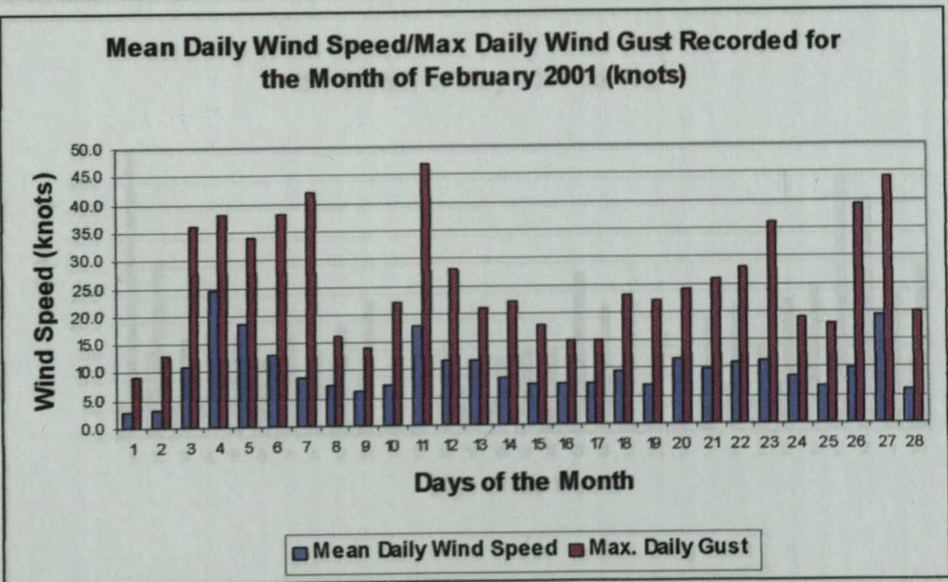


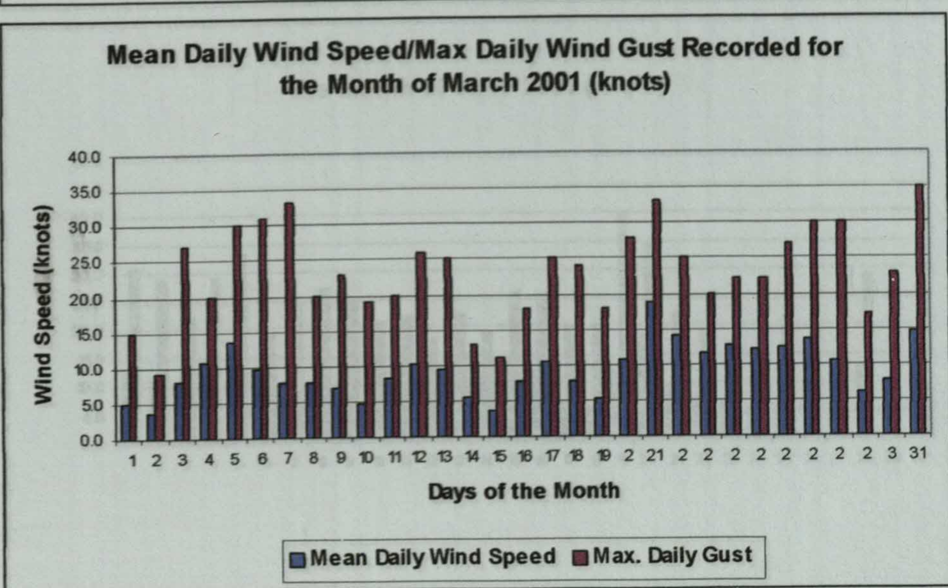
NO FEBRUARY 2003 DATA

Appendix 2

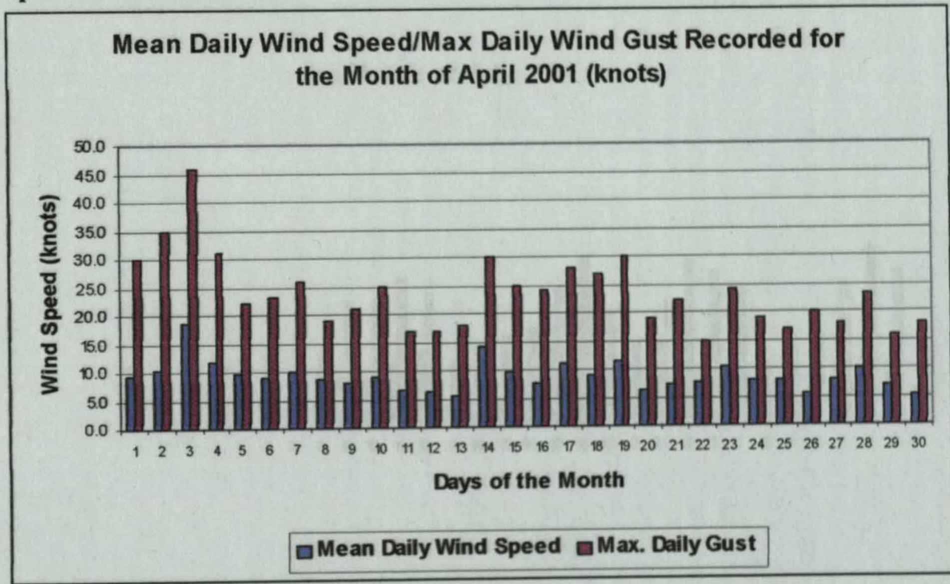
Mean Daily Wind Speed/Max Daily Wind Gust Recorded for January 2001 – April 2003 Inclusive

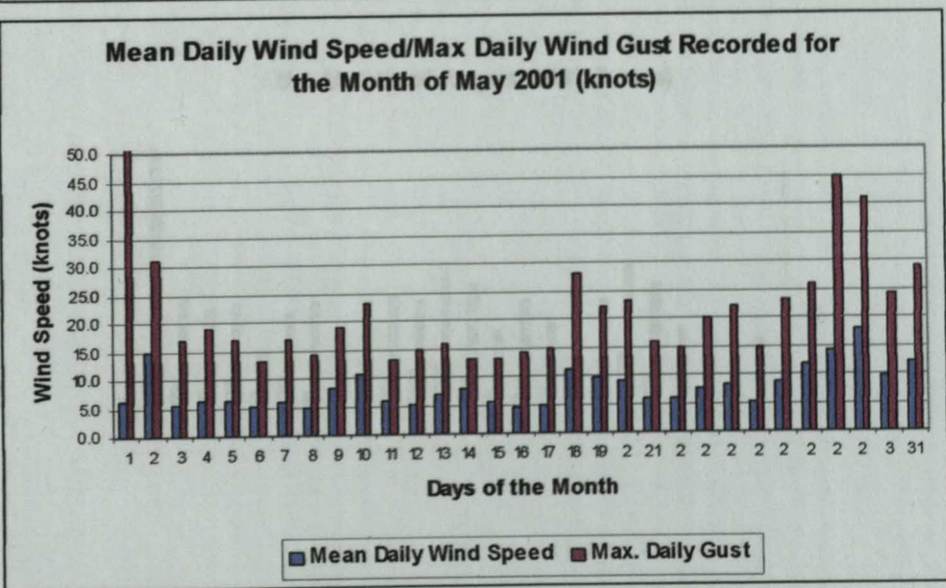


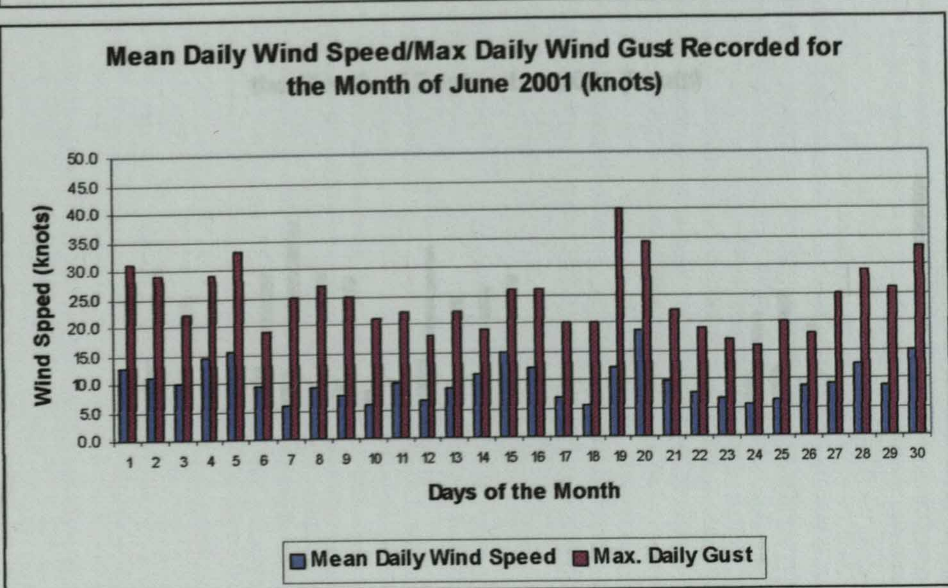




Appendix 2
Mean Daily Wind Speed/Max Daily Wind Gust Recorded for January 2001 – April 2003 Inclusive







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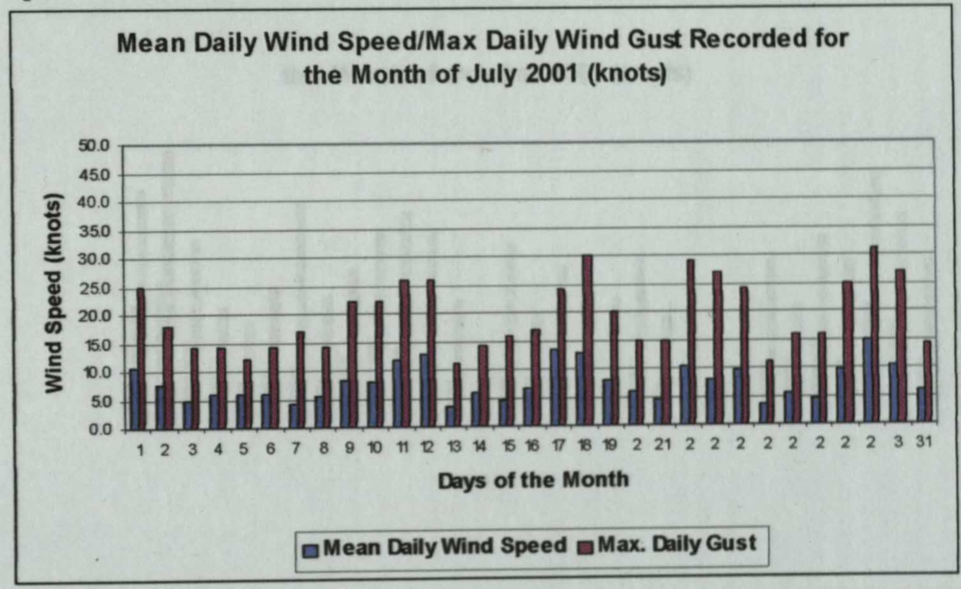

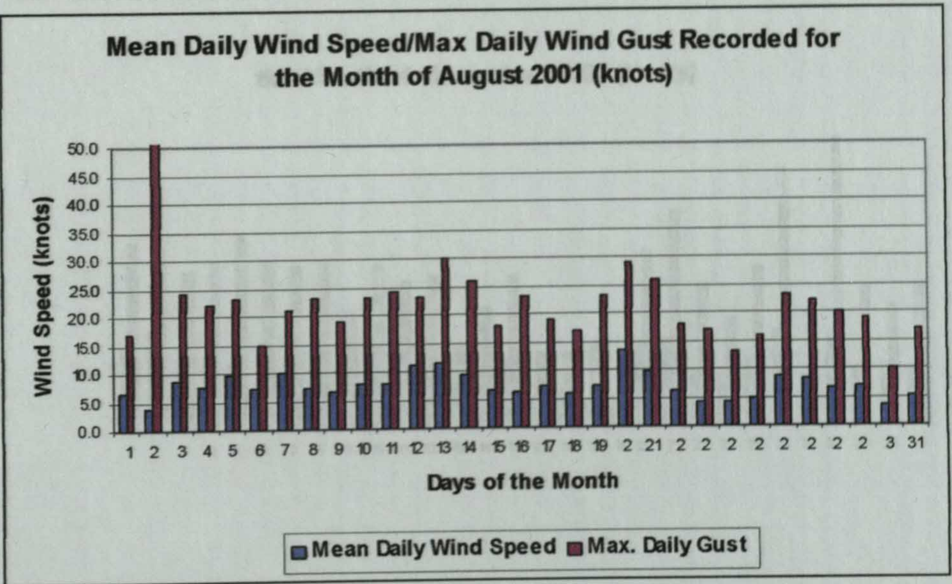

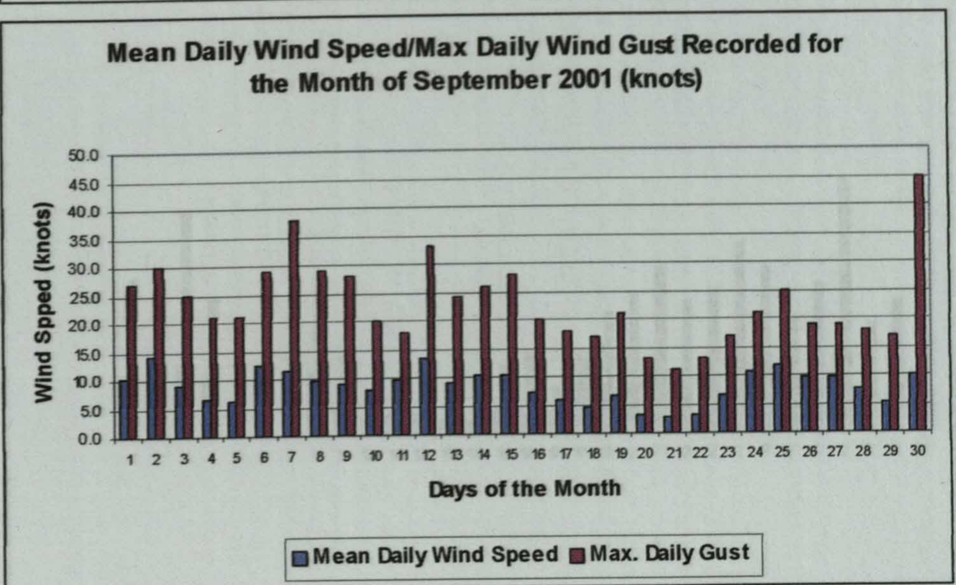

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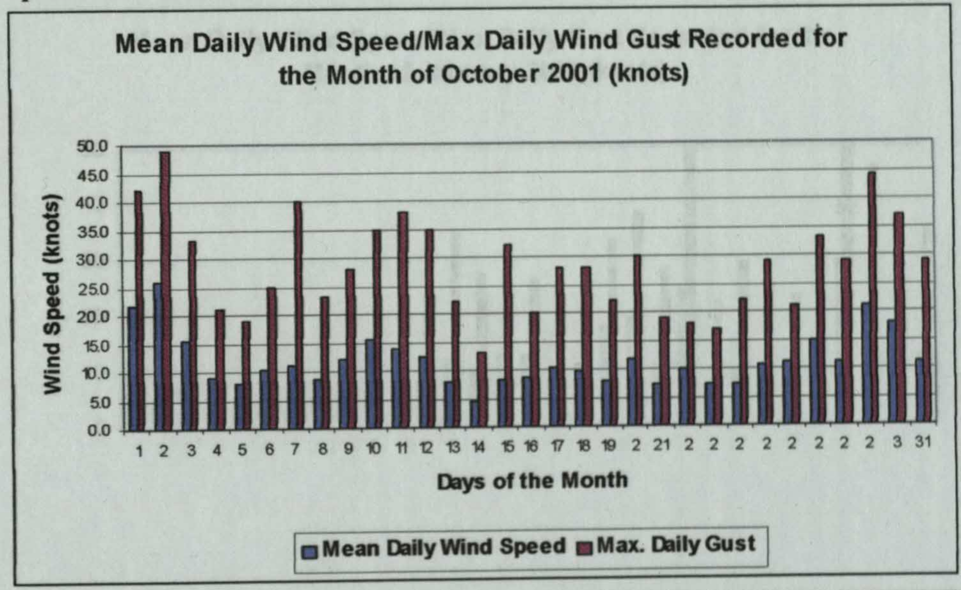

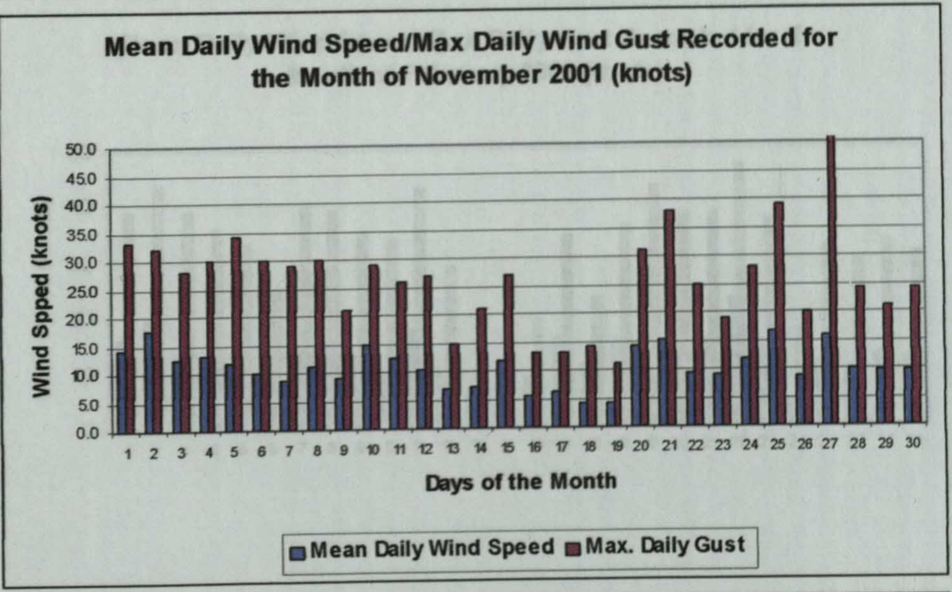

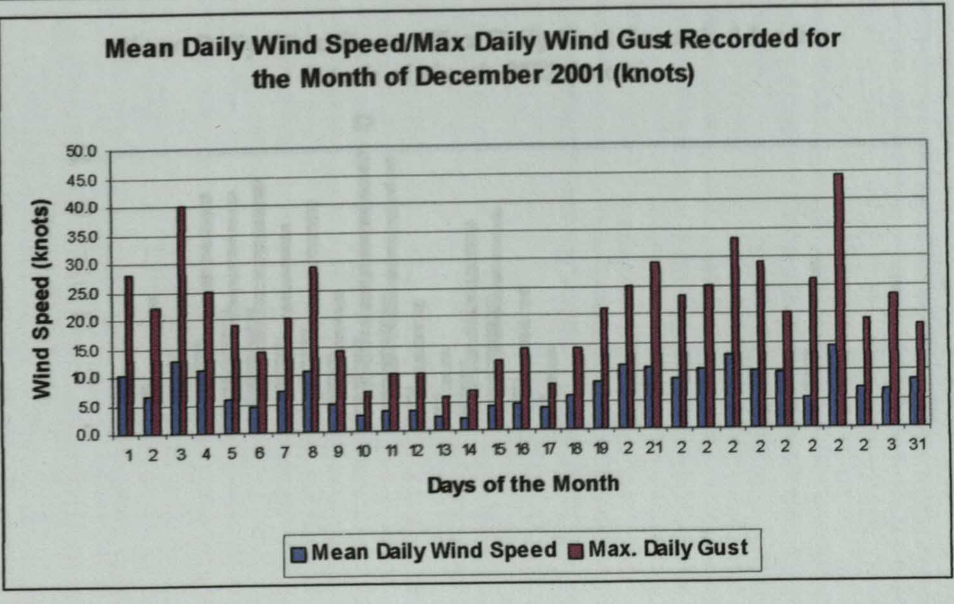

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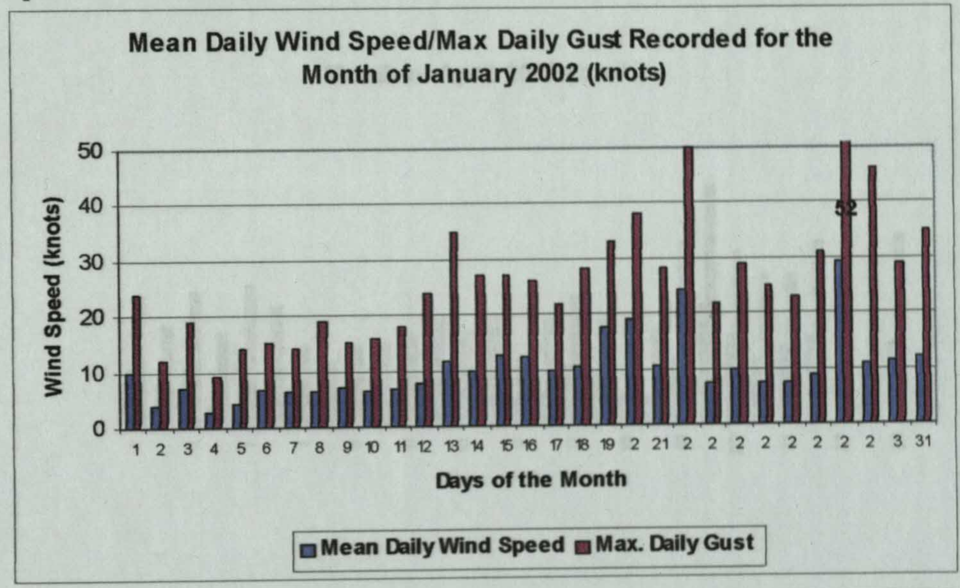

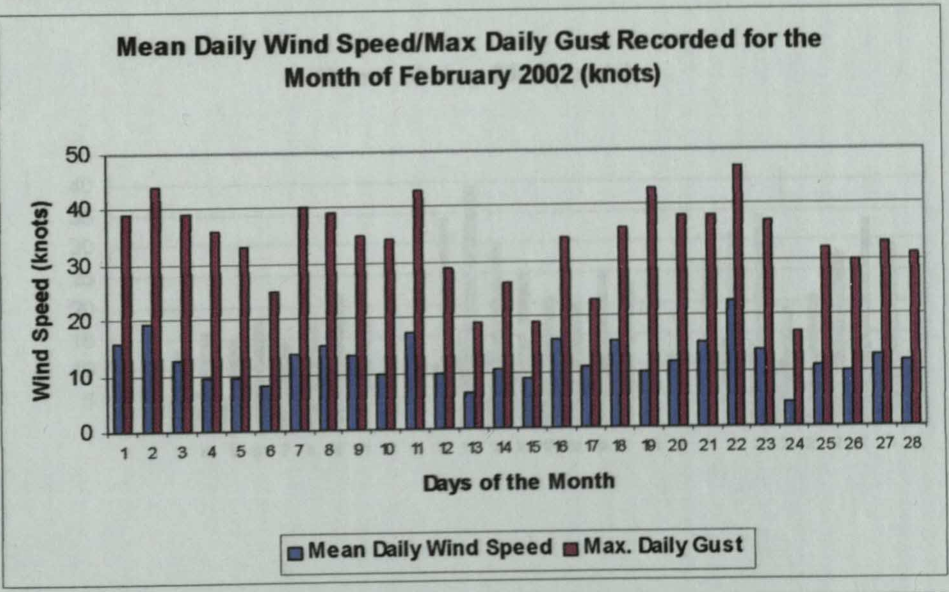

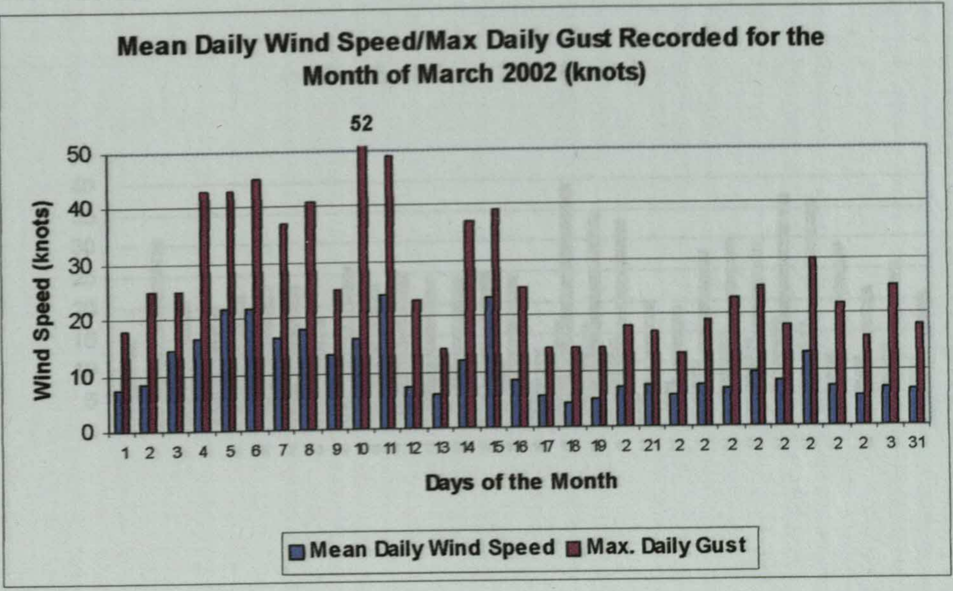

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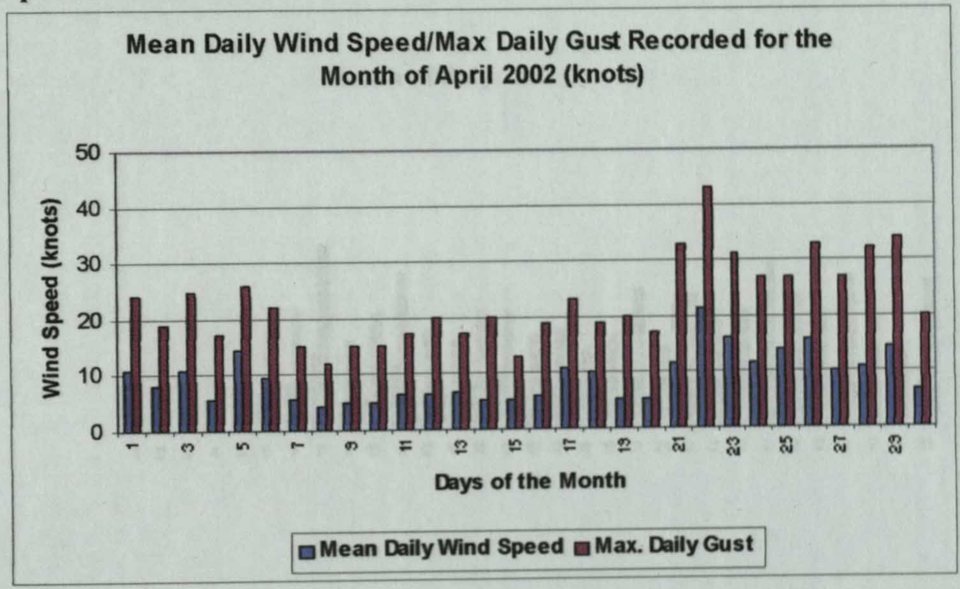

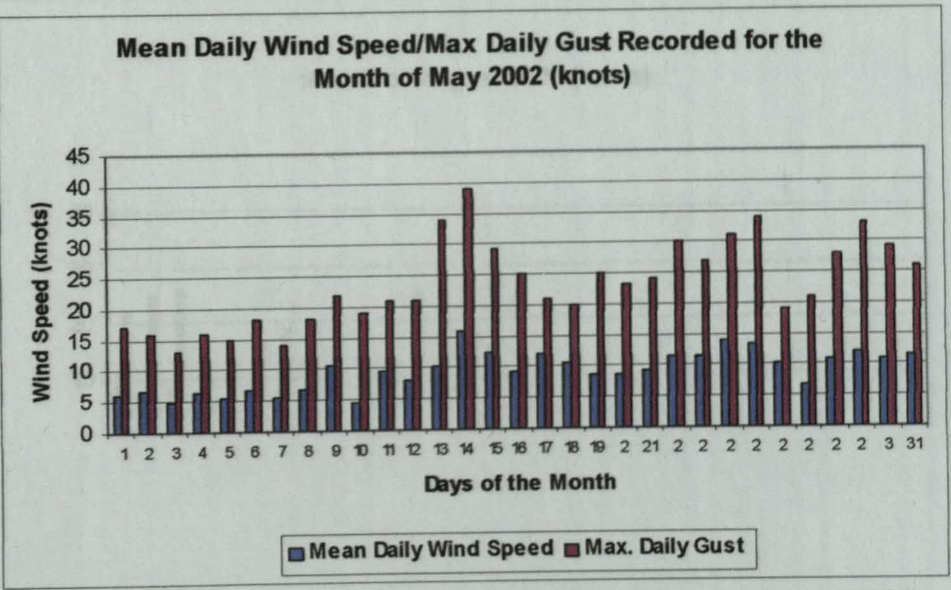

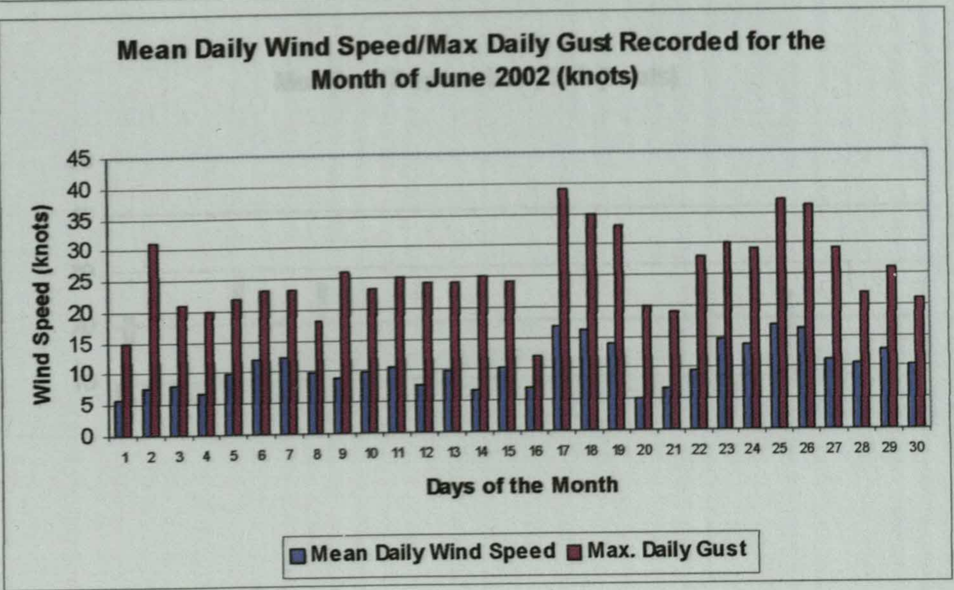

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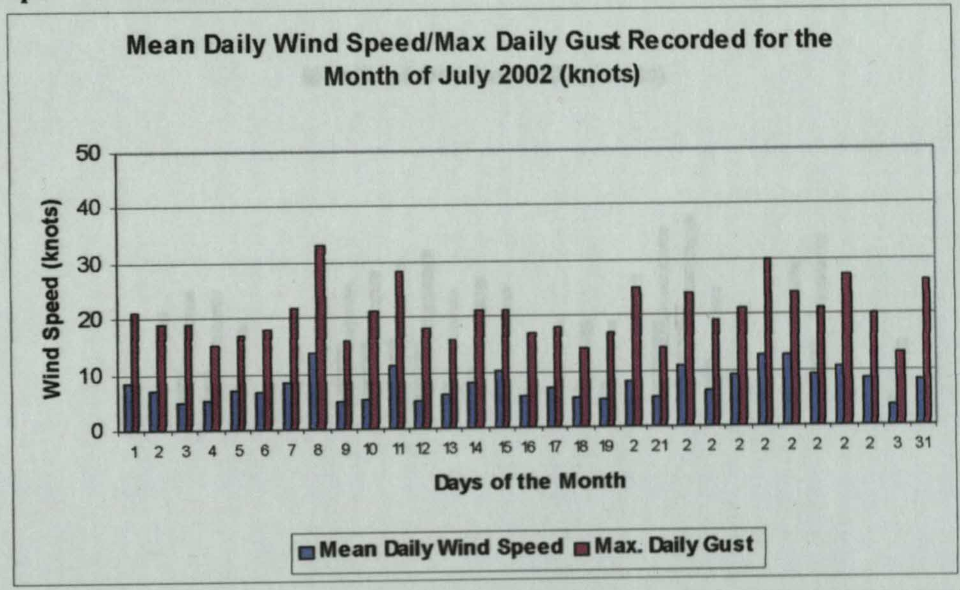

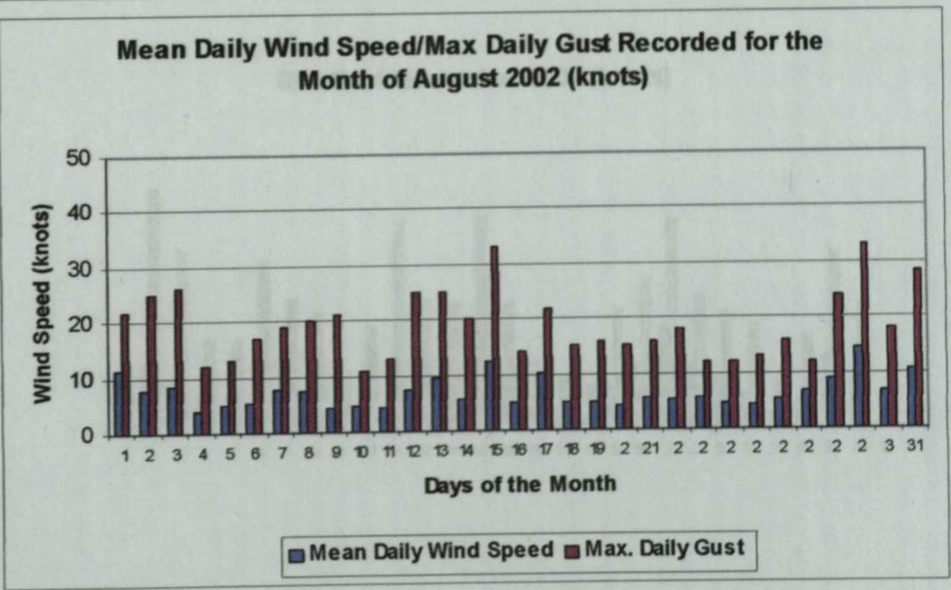

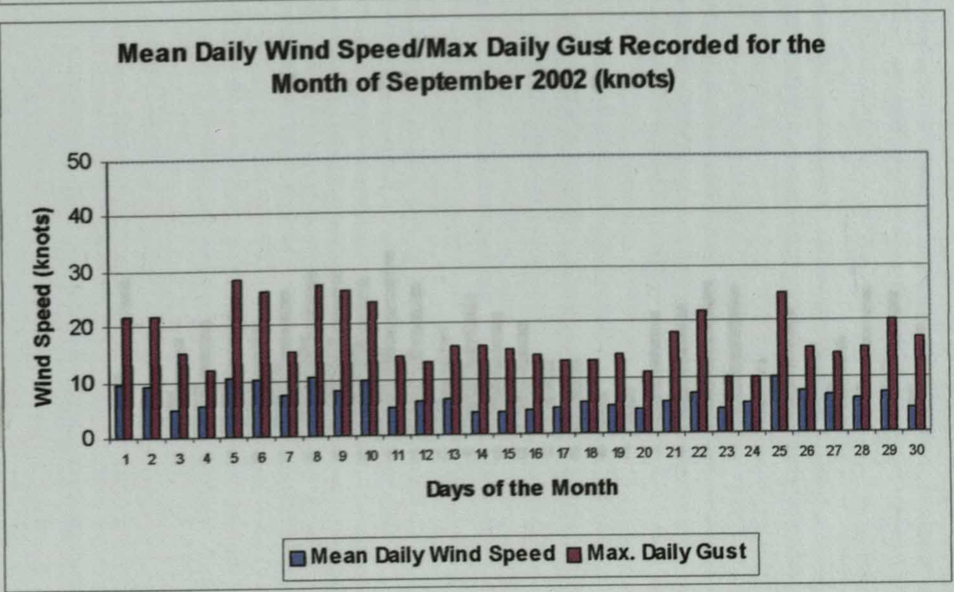

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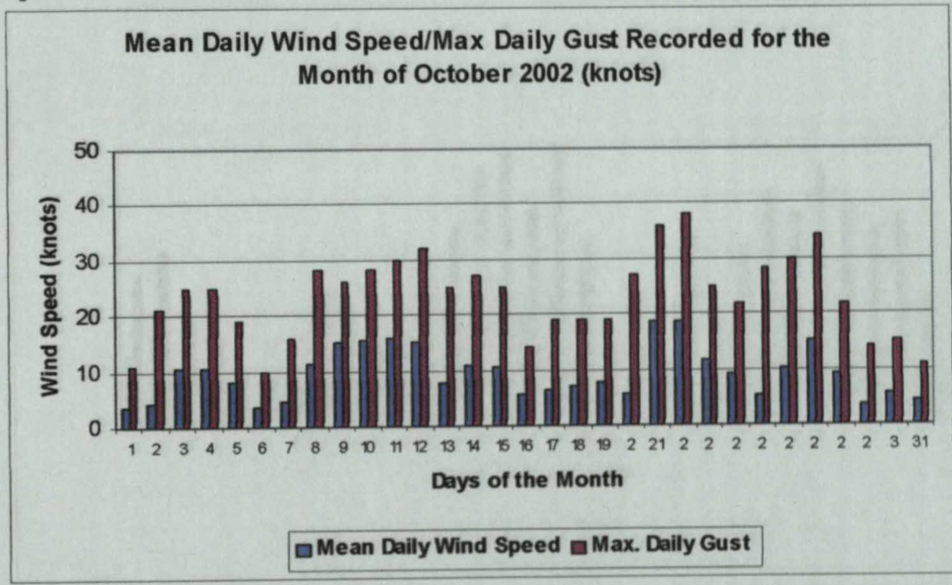

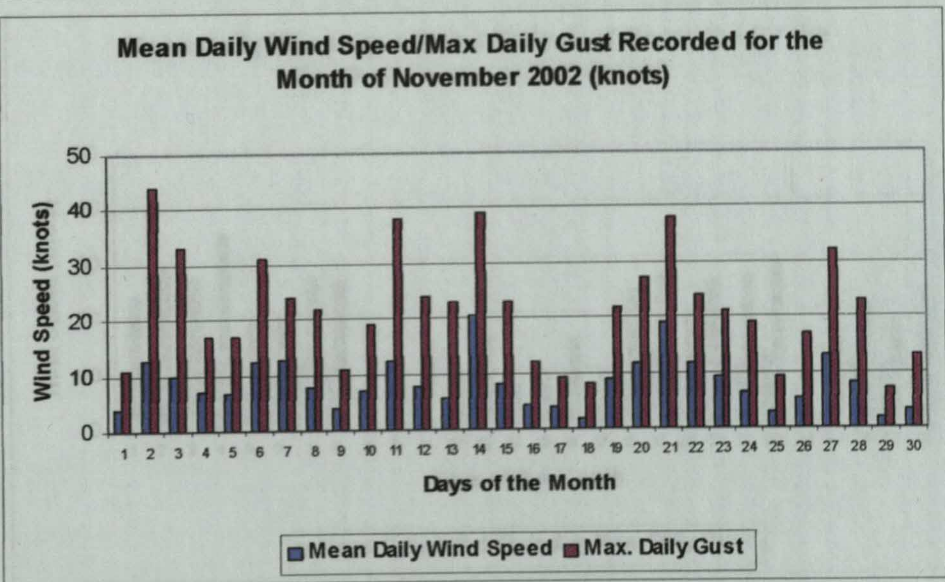

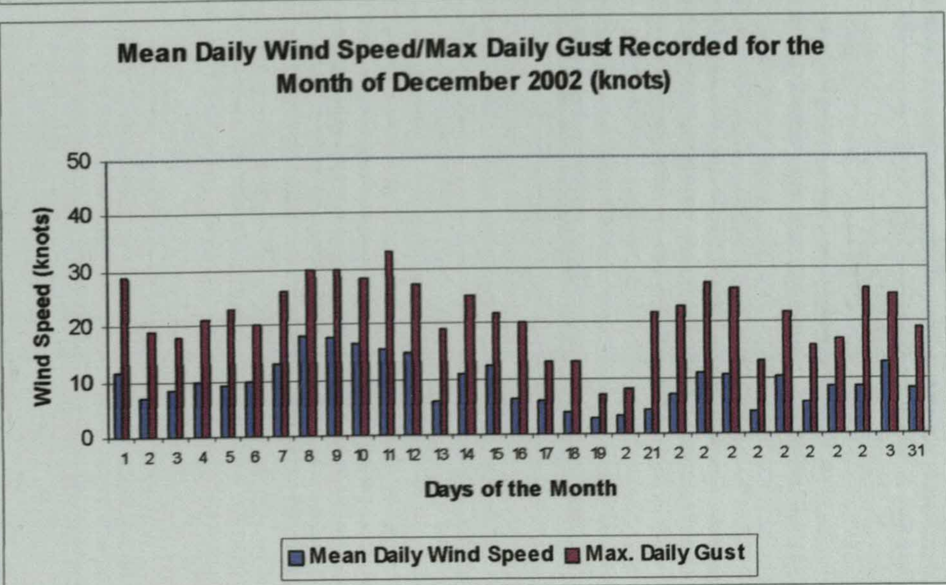

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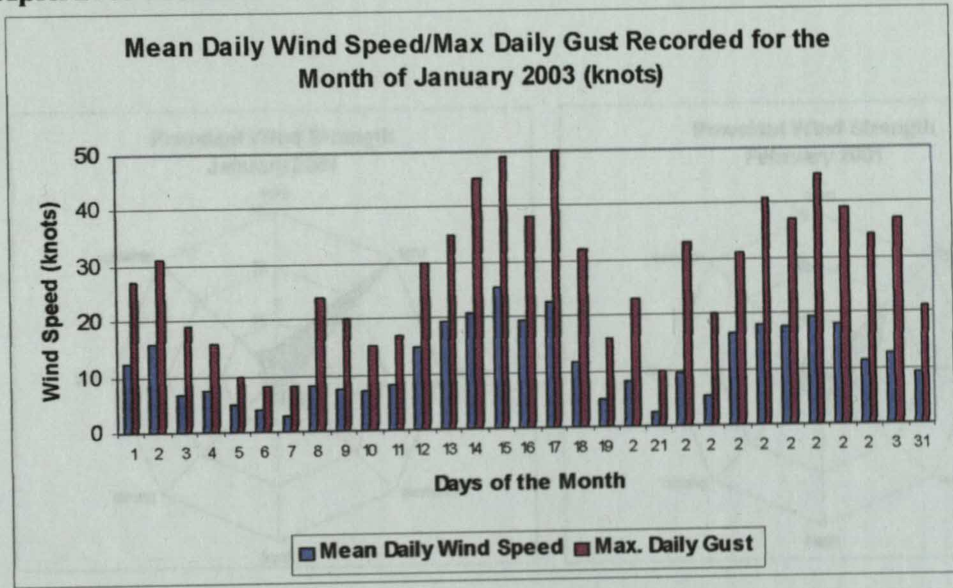
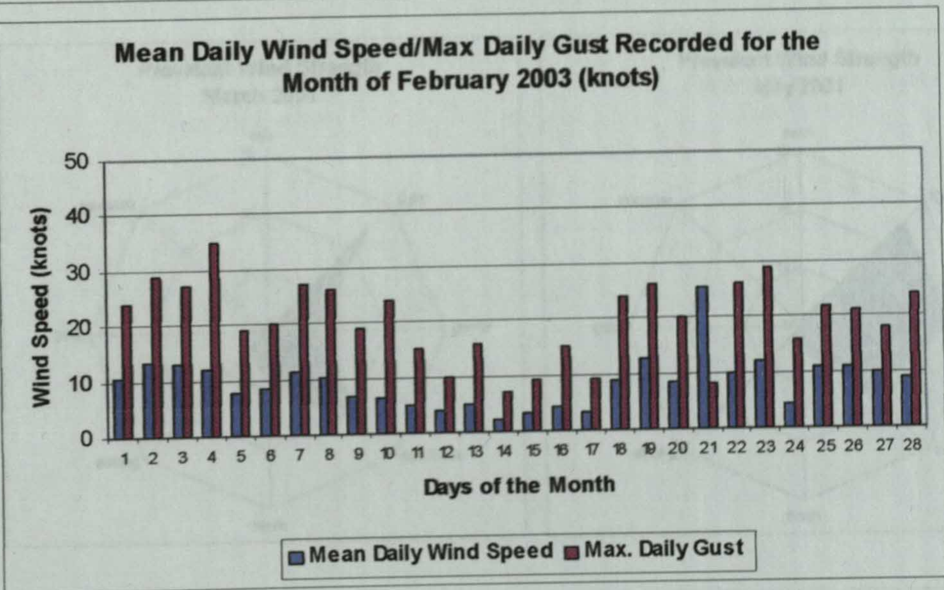
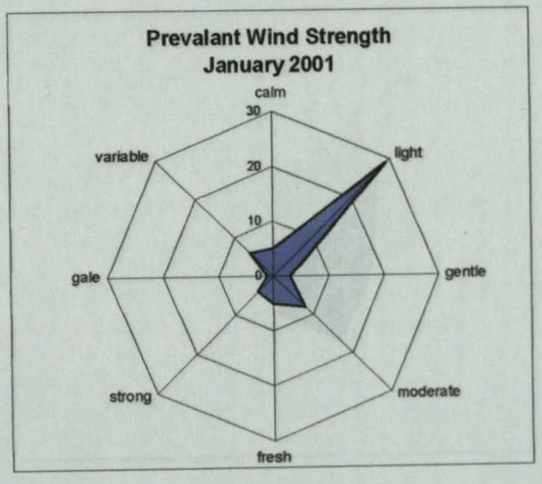
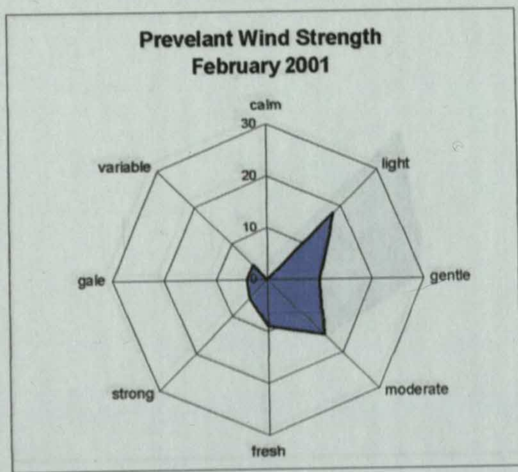
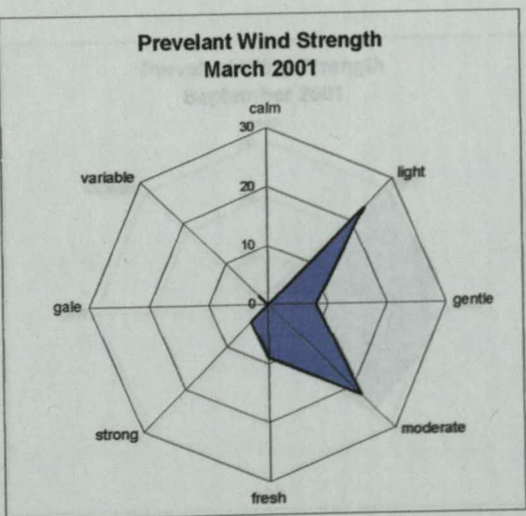


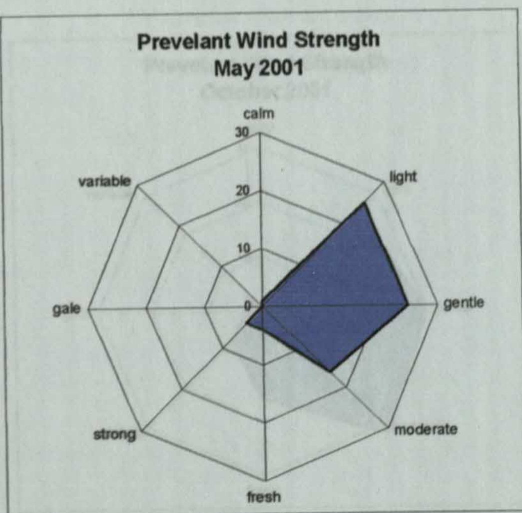


Appendix 2
Prevalent Wind Strength Recorded for January 2001 – April 2003 Inclusive









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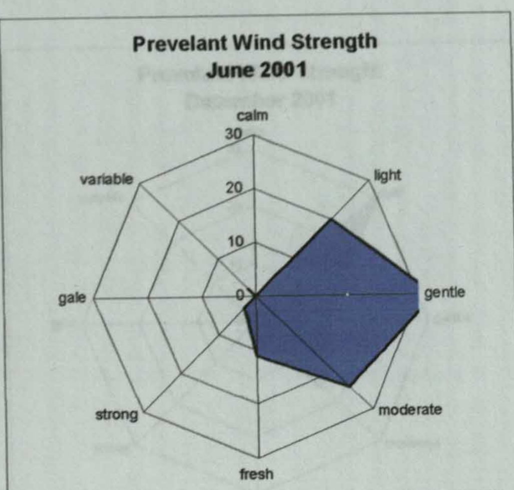

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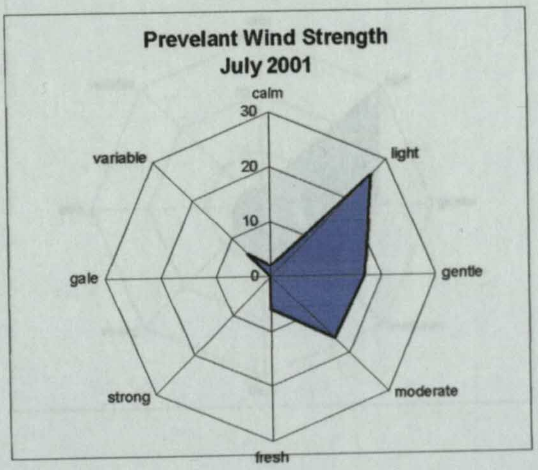
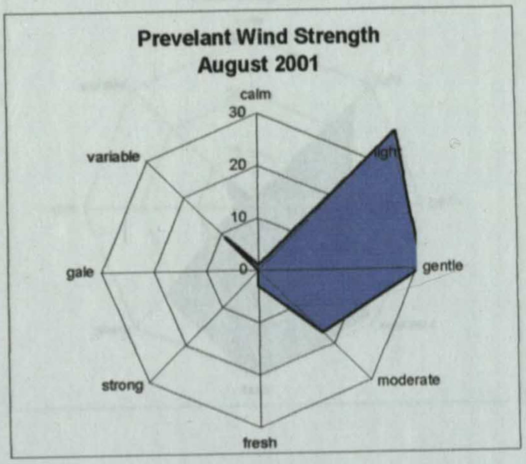
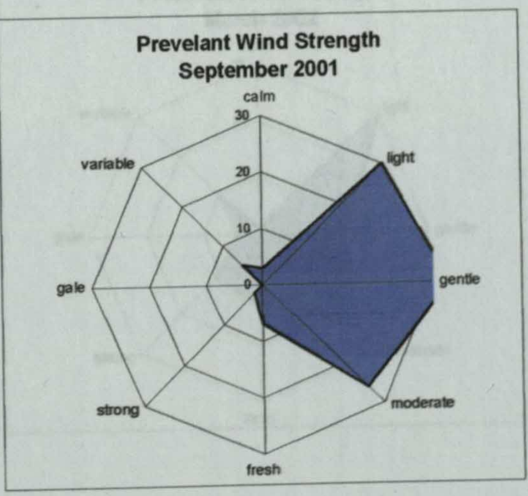
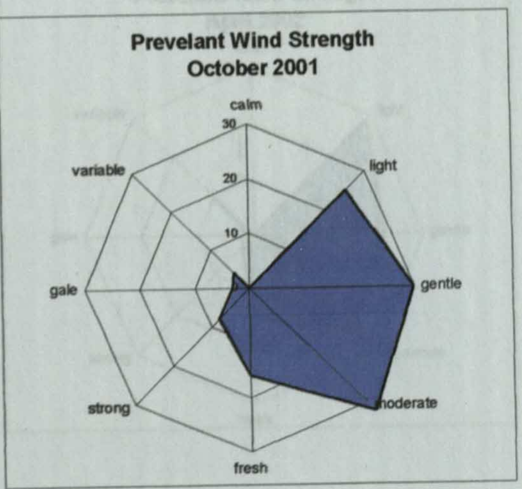
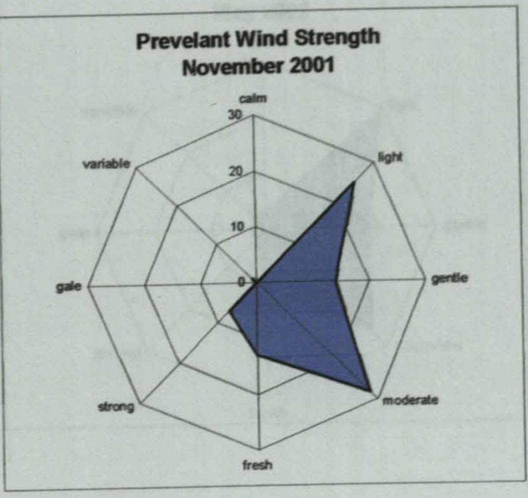
Prevalent Wind Strength Recorded for January 2001 – April 2003 Inclusive

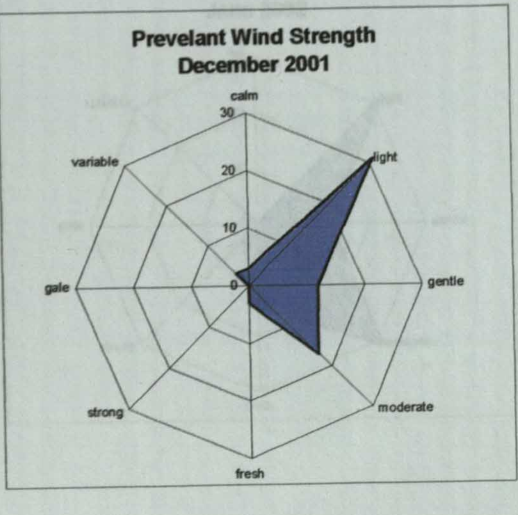












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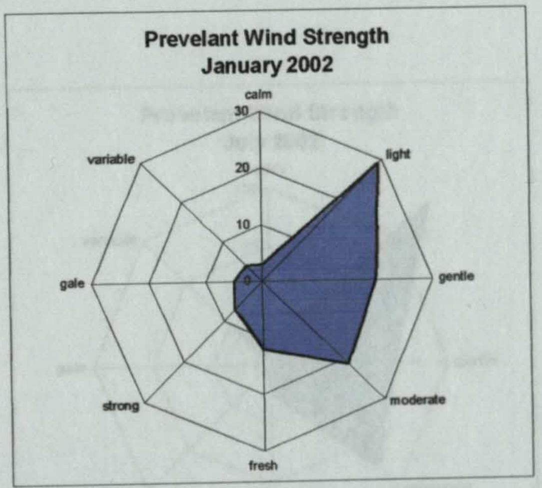

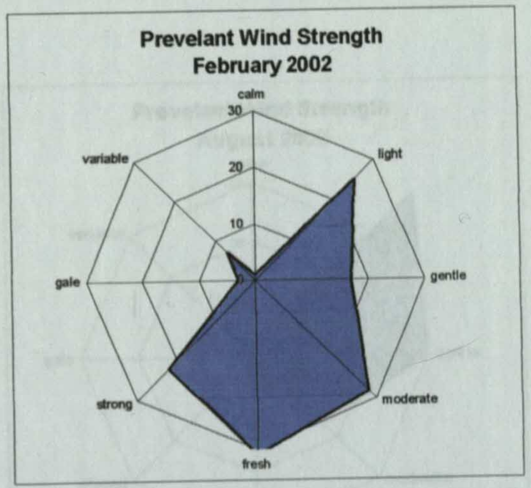

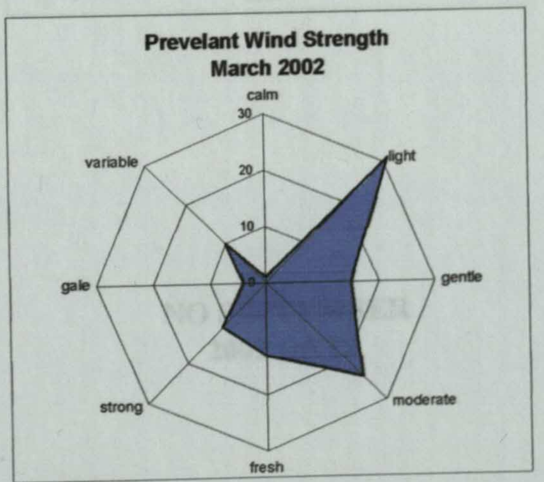

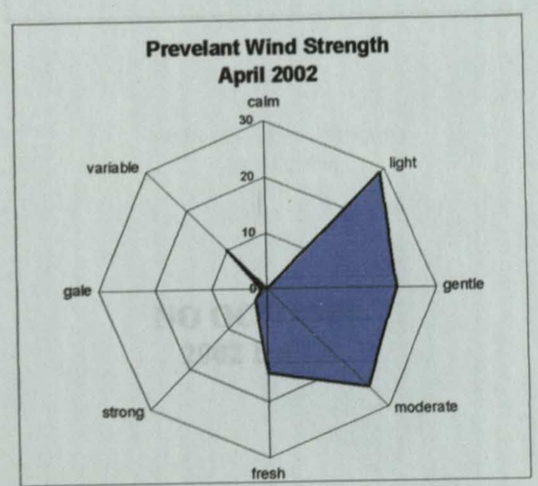

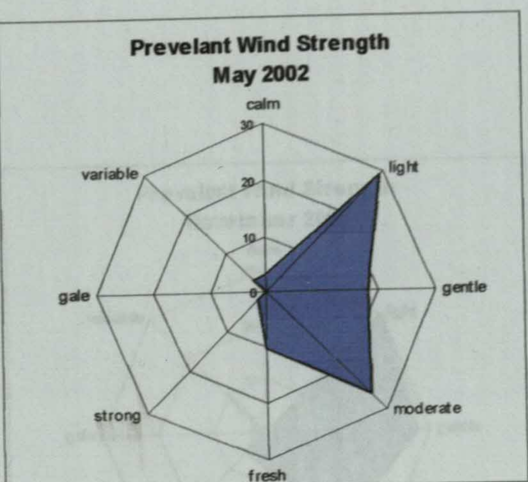

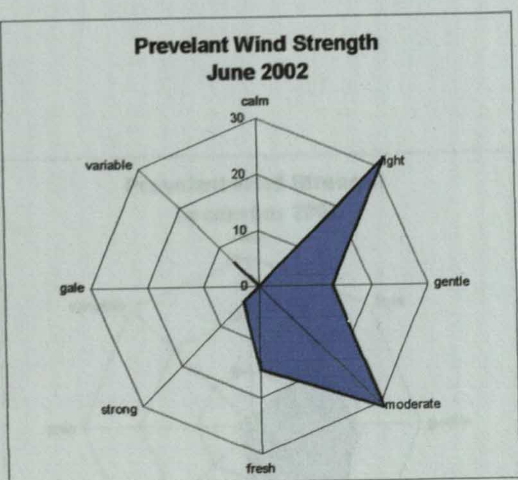

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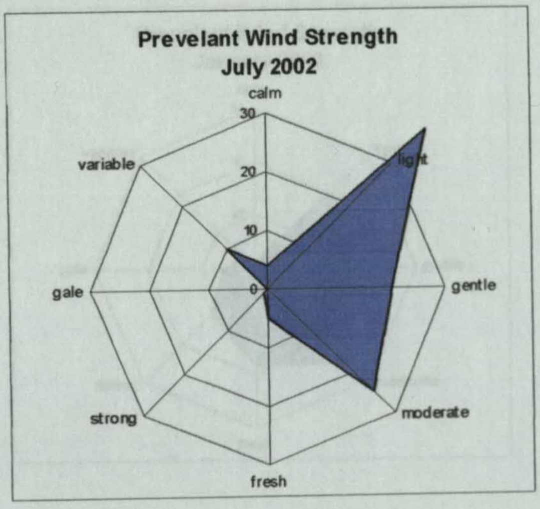

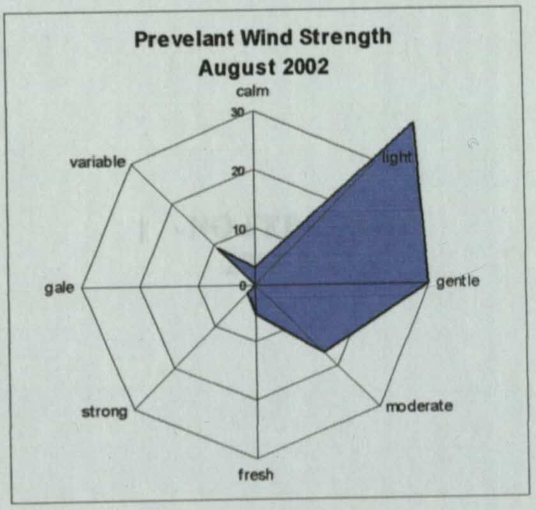

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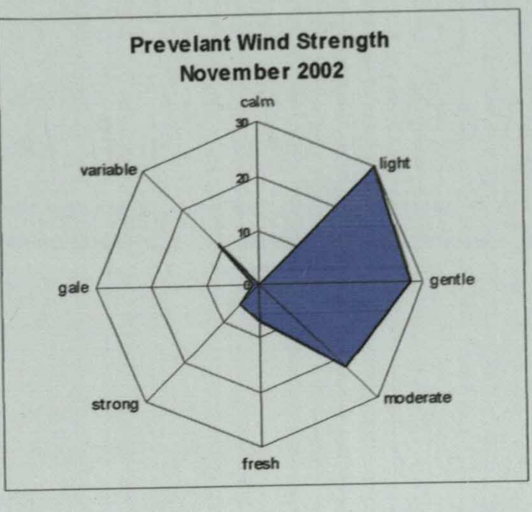

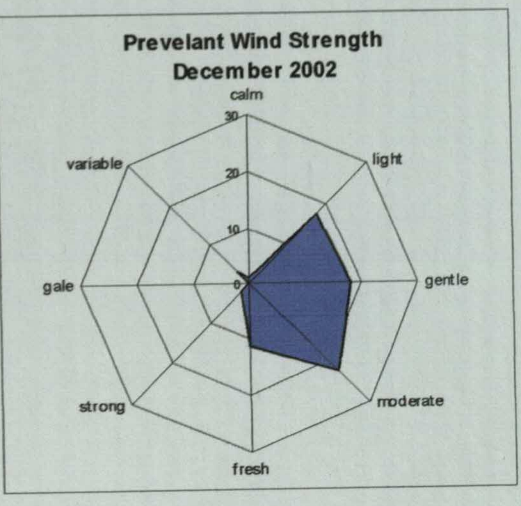

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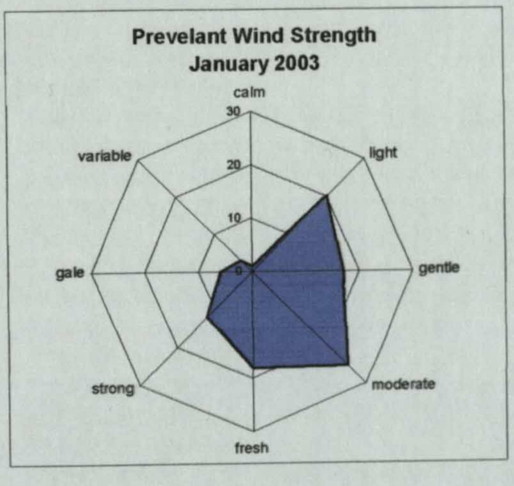

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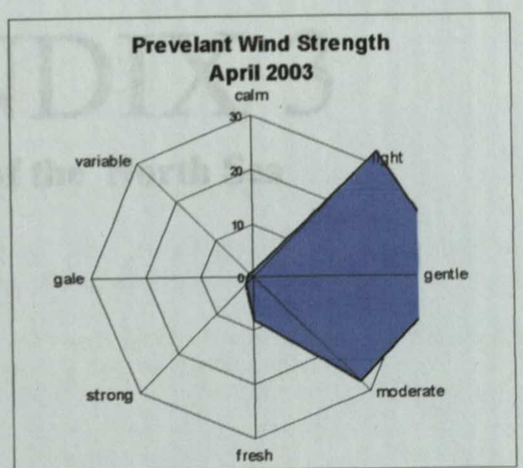

APPENDIX 3

Historic Storms of the North Sea

Historic Storms of the North Sea

For this appendix all data and information pertaining to the storms of the North Sea, and in some cases in particular to the St. Andrews area, have been sourced from:
Lamb H (1991), ***Historic Storms of the North Sea, British Isles and Northwest Europe***, Cambridge University Press, Cambridge.

The storms were catalogued by Lamb as they had acquired historical note in that they were seen as storms of great severity.

They were ranked by looking at two factors; the greatest winds speeds measured in gusts (Beaufort Scale) during the storm and the greatest winds speeds recorded over a period of either 10 minutes, or more usually, over an hour. Lamb also considered the greatest area covered at any stage by winds causing widespread damage – using winds over 50 knots as criteria for a damaging wind.

The severity of storms also considered in terms of looking at the following criteria:

* Total Damage to the landscape, particularly to coasts e.g. by sea floods, erosion caused by wave action, or blown sand and sediment transported by the currents and the waves
* Total damage to property and buildings
* Numbers of human and animal lives lost
* Insurance claims arising and costs of restoration and measures for future protection

and by calculating the following equation:

$V^3max \times Amax \times D$

*Where ***Vmax*** is the greatest Surface Wind Speed

****Amax*** is the greatest area affected by damaging winds

***D** is the overall duration of occurrence of damaging winds

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Storm # 1

Date: 5th, 8th – 15th, 18th –25th January 1552

Area: North Sea (all of the British and Continental coasts) and Western Europe

Observations: Great wind storms, accompanied by hail, snow and thunder. North Sea tidal surges and widespread flooding, particularly affecting the coasts of England and Scotland

Meteorology: The weather sequence suggests that the event began with a mild southwesterly wind, which was ended by a sharp cold front bringing a strong gale from a NW'ly direction

Storm Severity Index: None noted

Storm # 2

Date: 1st – 2nd, 11th – 12th November 1570

Area: Storm over the whole of the North Sea and severe inundation of the continental coast

Observations: Hennig (1904) claims that this was '…the greatest North Sea flood after that of 4/2/1825…' Gottschalk (1975) reports '….This was one of the great storm surges…The effects felt all along the whole North Sea coast….'

Meteorology: There was a slow eastward march of a cold front dividing a SSW windstream ahead of the front from NW or NNW winds advancing behind

Storm Severity Index: 6000

Storm # 3

Date: 14th – 18th August 1588

Historic Storms of the North Sea

Area: Northern North Sea off Scotland's east coast and among the Northern Isles

Observations: Ships of the Spanish Armada reported '…A very great gale at SW…A great storm at WSW…' and from '…13th – 18th we experienced squalls, rain and fogs with a heavy sea, so that it was impossible to distinguish one ship from another…'
Sir Frances Drake also reported on the 15th August '…A great storm considering the time of year…'

Meteorology: The strongest winds were from WSW on the 14th and SSE on the 16th
It seems clear that two depressions were successively involved and that the centres crossed both the British Isles and North Sea Region, broadly from west to east

Storm Severity Index: 600

Storm # 4

Date: November 1654 and February 1655

Area: Firth of Forth and eastern Scotland

Observations: Great winds felled trees in Fife and blew ships out of harbours
Further severe and protracted storms in the same area in February 1655 were followed by a long frost

Meteorology: None noted

Storm Severity Index: None noted

Storm # 5

Date: 10th December and 20th December 1655

Area: East coast of Scotland, Fife and Lothian, Firth of Forth

Observations: From the diary of John Lamont of Newton (the factor on an estate in the southeastern part of Fifeshire) '…All that day…it did snow, but at night ther fell extraordinary much snow, and all that night ther blew a great wynde, which occasioned great losse and damage to the shore of Fyfe, both by sea and land. As for the sea, it did flow…far above…its banks…[There] were many small barkes and other vessels that perished, lying in harbours…Also peirs were dung downe in severall places, as in St. Andraes, Eastor, Craill, Wemys, Leith…'

Meteorology: From the distribution of damage it is reasonable to suppose that the storm wind blew from an easterly direction

Storm Severity Index: None noted

Storm # 6

Date: 16th & 26th December 1658

Area: East coast of Scotland, Fife and the Firth of Forth

Observations: John Lamont reports '…a great tempest of wind and rain…' on this day followed by a long period of snow
There also came a sea flood where some people were drowned on the coasts of the Firth of Forth

Meteorology: It is hard to judge the wind directions involved in this incident, possibly a gale from between NE and SE with temperatures no higher than +1 to 5ºC is likeliest

Storm Severity Index: None noted

Storm # 7

Date: 2nd – 4th December 1662

Area: Firth of Forth and eastern Scotland

Observations: A great storm destroyed much of the Fife coastline, in particular the partly built new harbour at Dysart
A large ship was blown out into the Firth of Forth and destroyed

Meteorology: None noted

Storm Severity Index: None noted

Storm # 8

Date: 29th & 30th April 1663

Area: Coast of Scotland

Observations: John Lamont noted '…a great wynde and rain…' wrecked two ships from Newcastle on the coast of St. Andrews, with the loss of 36 lives

Meteorology: Judging from the shape of the coast, this was probably a NE'ly storm

Storm Severity Index: None noted

Storm # 9

Date: 3rd February 1667

Area: Eastern Scotland, Edinburgh, Fife and the Firth of Forth

Observations: John Lamont reported '…a great speate of water at Largo…' with thawing snow, brought about a rise in water levels
Several bridges all over Fife were destroyed, and farm building damaged due to the winds

Meteorology: There can be no clear diagnosis of the wind direction in this case, but from the locations it seemed a S'ly wind was likely, a gale from some point between SE and W can almost certainly be deduced

Storm Severity Index: None noted

Storm # 10

Date: 23rd October 1669

Area: East coast of Scotland

Observations: A great storm of wind, rain and thunder arose in the night and caused great losses both on land and sea

'…In divers harbours…vessels were broken and clattered…as in St. Andraes, Crail, Enster, Pittenwyme, Ferry, Wemyss…'
Trees were uprooted in many places

Meteorology: This was probably an easterly or northeasterly gale, which raised the water level in the Firth of Forth and the Tay
The sea flood seems to have been up a metre or two above normal high tide level

Storm Severity Index: None noted

Storm # 11

Date: The winter of 1681-1682

Area: Scotland

Observations: R.C. Mossman (1898) notes that in the winter of 1681 there were very severe storms of wind, although does not mention the direction of wind

Meteorology: Evidence suggests this was likely to be predominantly W'ly

Storm Severity Index: None noted

Storm # 12

Date: Approx. 16th – 26th November 1689

Area: North Sea

Observations: A fleet of 30 ships of the Danish-Norwegian navy sent to help the English King in his wars against France and Ireland, was beset by storms that affected most of the North Sea coastlines
So strong were the conditions that by the end of the storm the fleet were obliged to throw overboard a hundred horses and several men who had perished through the storm

Meteorology: At first the storm had become a headwind (W to NW), then the sea had become really wild, apparently with N'ly weather

Storm # 13

Date: 21st – 22nd September and 1st – 2nd October 1697

Area: North Sea, especially the north/northeastern coast of Scotland

Observations: Gottschalk reported the storm has reached notably high levels on most North Sea coastlines, resulting in severe inundation in many places

Meteorology: There are suggestions of a cyclonic system that produced an unusually severe gale from a westerly or northwesterly direction in the northern part of the North Sea

Storm Severity Index: None noted

Storm # 14

Date: 22nd October 1702

Area: Northern Scotland, Moray Firth and North Sea coast

Observations: A storm, apparently from about WSW, but with the wind perhaps shifting later to NW, caused drifting of loose sands in many areas
Some exposed towns and villages were partially destroyed, although the old town of Findhorn was completely destroyed by the sea, which also caused a completely changed in the course of the River Findhorn

Meteorology: A suggestion that the outer coasts were battered relentlessly by a heavy northerly or northwesterly sea

Storm Severity Index: 500

Storm # 15

Date: 24th – 25th December 1717

Area: Whole of North Sea and it's coastline, in particular the British Isles

Observations: This was one of the greatest historically recorded storm disasters on the coasts of the North Sea in terms of loss of life
All in all it has been reported that 11,000 people and 90, 000 cattle died
There was storm damage and flooding all along the coasts of the North Sea
Fortunately it was reported that this was not a spring, had it been there is no doubt that the tide would have been considerably higher

Meteorology: SW and W gales that veered into NW winds, with the inclusion of a cold front accompanied by dry wind

Storm Severity Index: 6000

Storm # 16

Date: 15th – 19th September 1740

Area: North and Sea and England

Observations: Lowe (1870) reported '…S'ly gales….much damage to shipping…'
Meteorological data confirms a SW'ly gale through the day on the 18th increasing to a S'ly storm in the evening, with thunder squalls
A ship, SS Dronning of Denmark, anchored in the North Sea, reported a SSW force 10 for some hours in the middle of the day on the 19th, preceded by SSE force 5 in the night before

Meteorology: The situation seems to have been becoming increasingly cyclonic over the time period in the northern North Sea

Storm Severity Index: 500

Storm # 17

Date: 12th November 1740

Area: North Sea and coasts of Scotland and Northern England

Observations: Gales blew down church spires, blew tiles and roofs away from houses and farm buildings

Thomas Short (1749) reported '…November 1st was a memorable day, with a N wind, snow, sleet, hail, rain and floods….and a hurricane from 6th at night to 12th, wind N and NE the terriblest of many years; it did inestimable damage…..to shipping, goods and people's lives…'

Meteorology: A deep low pressure centre moved northeast across the British Isles and the North Sea
Strong to gale NW'ly winds with low temperatures (5°C at midday), associated with a previous cyclonic systems
The low pressure system probably moved east to southeast and over the continent by the 13th
A key part in this sequence is the presence of such cold air
The winds were persistently between NW and E

Storm Severity Index: 800

Storm # 18

Date: 11th September 1751

Area: All of the North Sea and Denmark

Observations: **This storm was classed as one of the three of four highest storm surges of the Century, although this was no lost of life, or damage to land/property as many sea defences had been built round many coastlines by this point**

Meteorology: Winds from between SW and S, in some places SSE, increased to a force 9/10 then veered sharply to WNW and NW and continued to blow at these high strengths for 12 hours or more

Storm Severity Index: 2500

Storm # 19

Date: 7th October 1756

Area: **Southern and central North, later on also most of British coastline, also Danish, Dutch and German coastlines affected**

Observations: Reported, at the time, as the most violent winds ever seen in Britain, numerous trees blown down or twisted off their trunks by tornadoes
Pieces were blown off stone buildings, sea salt was blown inland, some houses were blown down, ships sunk and overturned in harbours and others blown out to sea
There is no mention of loss of life

Meteorology: Storm winds from SW, later veering WNW
Temperatures fell, which introduced the violent (damaging) winds, and bringing about a North Sea surge
The heights attained by this tidal surge suggest that during the latter part of the storm a strong NW to N'ly gale was also blowing over the North Sea

Storm Severity Index: 4000

Storm # 20

Date: December 1761

Area: North Sea

Observations: A Dutch Ship, anchored in the northern North Sea, was driven loose by violent S'ly gales and driven helpless, without sails for many miles

Meteorology: A high percentage of S'ly, SW'ly and W'ly winds blew across the British Isles through the winters of 1760-1 and 1761-2

Storm Severity Index: None noted

Storm # 21

Date: 20th April 1773

Area: Eastern Scotland, probably also the northern North Sea

Observations: Unusually severe gale blew down 400 trees
N'ly or NW'ly wind presumed

Meteorology: A great prevalence of N'ly winds was reported

Storm Severity Index: 300

Storm # 22

Date: 23rd – 26th December 1783 and the first days of January 1784

Area: Northern North Sea and eastern Scotland

Observations: A violent E'ly storm on the 25th & 26th December wrecked three ships on the Scottish coast
Gales brought snow to several parts of eastern Scotland
On the 2nd and 3rd January many, many houses in eastern Scotland were unroofed, rocks were blown into some harbours and stacks of corn and hay were carried away

Meteorology: These storms occurred in the early stages of a long period of severe weather, with mainly E'ly winds, they continued from early in December until well into January
Apart from some very small breaks in the pattern the weather remained severe and the winds from between NW and E dominated

Storm Severity Index: 400

Storm # 23

Date: 14th – 15th September 1786

Area: British Isles, North Sea and its continental coasts

Observations: Information recorded from ther correspondence of a farmers wife living at Kemnay, Donside reported '…A hurricane of wind in many parts….threw down houses, overturned coaches and wagons and killed many people…'
There was much loss of life at sea

Meteorology: This was a WSW'ly gale of damaging strength over a broad belt of the country
The barometric pressure indicates the winds likely reached speeds of 80 knots, in a cold, unstable air stream with many showers, frequently heavy

Storm Severity Index: 100

Storm # 24

Date: 7th – 8th December 1792

Area: The whole of the North Sea, also Denmark and southern Baltic

Observations: Stormy winds from NW and notably high flood tides

Meteorology: Another cyclonic centre, associated with warm air crossing over the UK, amalgamating with deep low pressure systems from the north

Storm Severity Index: 1200

Storm # 25

Date: 10th – 12th December 1792

Area: The whole of the North Sea, and as far north as the Faeroe Islands

Observations: Winds of great violence were reported, mainly W'ly, but soon NW'ly
On the night of 10th-11th December this storm produced some of the highest flooding of the century (5.88m reported in some places on the British Isles and the continent)
Reports of '…people remembering nothing like the winds of these three days…'. Strong gales and '…a great wind…' from the W were reported widely on the 10th

Meteorology: Again cyclonic systems brought a warm air stream over the British Isles that amalgamated with major activity farther north

Storm Severity Index: 12 000

Storm # 26

Date: 19th –23rd December 1792

Area: Initially the southern North Sea, then the whole of the North Sea by 21st-22nd

Observations: On the 18th, with falling pressures over the whole region, W'ly winds were reported to be strengthening
On the night of 18th-19th the W to WNW were described as being very strong, and by the 21st described as a very 'hard wind'
By the 23rd there were reports of the winds being '…as high as has been known for a long time…', particularly on the eastern coast of Scotland

Meteorology: Evidence of vigorous cyclonic activity and frontal systems were accompanied by other systems passing east across Britain, bringing mild and humid air

Storm Severity Index: 1000

Storm # 27

Date: 6th – 12th May 1795

Area: North Sea and Scandinavia, from the east coast and costal regions of Scotland to the east coast of Sweden

Observations: Reports of whole forests felled by the wind, many trees broken halfway up their stems and heaps of trees left lying in top of one another
Some of these descriptions suggest that in some localities tornado activity was also involved

Meteorology: A period of quiet, warm weather over most of Europe, by the 4th May a belt of winds from WSW to W were strengthening across Scotland
On the 10th-11th May another frontal wave disturbance travelled southeast over the North Sea from the north of Scotland, producing a cyclonic centre

Storm Severity Index: 3000

Storm # 28

Date: 12th – 16th January 1818

Area: Scotland and all Scottish coasts, Denmark

Observations: Buildings all over Scotland were reported to be severely damaged by W'ly gales, as well as trees being blown down

Meteorology: This was a very mobile spell of weather in the British Isles latitudes with rapidly occluding low pressure centres
The warm SW'ly air from the subtropical Atlantic brought warmer temperatures
The sequence was then seen to be characterised by much colder maritime Artic air, repeatedly intruding southwards in the rear of each depression, bringing the temperature right down again

Storm Severity Index: 3000

Storm # 29

Date: 2nd – 5th February 1825

Area: Whole of the North Sea

Observations: A strong storm raged all day on the 3rd and continued until midday on the 4th
The wind had been WSW with much rain in the forenoon of the 3rd, and veered through W to WNW in the afternoon and evening: all day it was a great storm with heavy squalls
After midday on the 4th the wind veered N and dropped lighter
From the afternoon of the 3rd onwards the air was mostly very clear but with some black clouds and hail and snow showers
Late in the evening on the 3rd thunder was reported and in some places continued for a considerable time
'…floods over low-lying coastal developed rapidly, damaging coastal villages ... thousands had to flee their homes in haste in their nightclothes …'
This storm was also notable for it's duration: three days on the German side of the North Sea, four elsewhere
As many as 800 people from all around the North Sea coastlines died, as well as many thousands of cattle
Thousands of buildings were also been destroyed
The entire 1824-5 winter was stormy

Meteorology: In late January the barometric barometer was generally high over the British Isles, but by 28th January 1825 an anticyclone with central pressure over 1040mb was centred over Wales that influenced the weather over the whole of England and Scotland
Farther north a sequence of intense depressions was passing from west to east in the Artic
The broad stream of westerly winds between Scotland and Iceland was of gale, or storm, strength with gradient winds approaching 100 knots

By 30th and 31st January the whole pattern had shifted south

Storm Severity Index: 12 000

Storm # 30

Date: 3rd – 4th August 1829

Area: Northeast and central Scotland, including Orkney. Gales also in eastern England and all waters of Scotland's north and east coasts

Observations: This storm has been reported (Lauder 1830, 1873) and remembered chiefly as an outstanding rainfall event, but the 'furious NE wind' raised high seas, which caused shipwrecks and broke open some Scottish harbours
There seems to have been little wind damage other then through the intermediary of the stormy sea
There was an interval of some hours, to probably most of one day of westerly wind over northern Scotland before the wind direction returned to N and NE and the gales set in
Measurements of rainfall are only available from places in relatively sheltered situations, the greatest being 95mm in 24 hours from 5am on the 3rd to 5am on the 4th
Those areas where the exceptional rainfall gave rise to the flooding of lochs and rivers to levels never previously reported, it is believed they've have never been equalled
Road bridges, houses and other buildings were reported damaged all over parts of Scotland
Many people lost their lives

Meteorology: Cyclonic centres had been moving in the southern North Sea since 25th July, occasionally bringing very high temperatures (up to 33°C) and thunderstorms to the British Isles
High pressure systems centred between Scotland and Iceland on the 25th and around the end of the month withdrew south and southwestwards
Artic air spread from the Norwegian Sea and the northernmost Atlantic swept south over Scotland from the 3rd August onwards
A vigorous depression moved south from the Artic from the north of Iceland to the northeast of Scotland
This merging of the southern and northern cyclonic activity presumably sharpened the thermal gradients in these areas

Storm Severity Index: 150

Storm # 31

Date: 14th October 1829

Area: Much of the North Sea, northeast Scotland and also Denmark and Danish waters

Observations: Many ships were lost in a NE'ly and N'ly gale at and near the northeast coast of Scotland

Meteorology: Cyclonic activity over the North Sea region had been 'fed' by frontal wave disturbances coming from the southwest, from the Biscay and Atlantic
The system deepened while still complex over the North Sea on the 14th
At the same time it was being forced somewhat farther south than before by changes in the high pressure system to the north of it
As the depression moved east, there was a substantial rise of pressure over Scotland and Ireland and a sharp recovery of the high pressure level over Scandinavia later

Storm Severity Index: 400

Historic Storms of the North Sea

Storm # 32

Date: 25th November 1829

Area: Coast of Scotland and probably all of North Sea coast of Britain on the 24th and 25th

Observations: Reported that an ENE'ly gale on this date wrecked many ships

Meteorology: The situation of a very broad belt of E'ly winds between high pressure over Scandinavia, and to the north of Scotland, and low pressure over France and central Europe
Strong gales of up to force 10 were reported on the 24th and 25th

Storm Severity Index: 300

Storm # 33

Date: Winter 1837-8

Area: Orkney, northeast Scotland and the northern part of the North Sea

Observations: A prolonged NE'ly gale caused the sea to scour many beaches

Meteorology: None noted

Storm Severity Index: None noted

Storm # 34

Date: 7th September 1838

Area: Northern North Sea, Northumberland and Scottish coasts

Observations: This storm has been made famous by the wreck of the passenger steam ship *S/S Forfarshire* on the Farne Islands, off Northumberland
Weather had deteriorated with a stiff breeze and the sea was getting up
The wind changed sharply to NNE, and of gale force

Meteorology: Cyclonic activity centred over the British Isles, with generally S'ly winds on the 5th, produced the lowest pressures during the 6th, and it's focused shifted stage by stage to the North Sea as an intensifying outbreak of N'ly to NE'ly winds was drawn onto the it's rear side on the 7th
Warm air from the SW produced temperatures up to 22ºC and was associated with a series of frontal waves and warm sectors arriving during these days
On the 8th a N'ly gale was still blowing on parts of the Scottish east coast and the colds air brought afternoon temperatures as low as 12-14ºC

Storm Severity Index: 100

Storm # 35

Date: 10th January 1849

Area: Northeast coasts of Scotland

Observations: A great E'ly gale and heavy seas washed away heavy harbour defences at Peterhead and Aberdeen
This E'ly storm seems to have affected northern Scotland while milder air and SW to W winds, which also developed top gale force, were pushed up from the south

Meteorology: None noted

Storm Severity Index: 150-200

Storm # 36

Date: 28th December 1849

Area: The North Sea coast of Britain

Observations: A great storm changed many parts of the coastline, including a 400m breach across the neck of the peninsula connecting Spurn Head at the mouth of the Humber

Meteorology: This storm came after nine days of quiet anticyclonic weather with about normal temperatures in Britain, with some sunshine and variable wind directions
It marked a sharp polar outbreak with NW'ly and N'ly winds spreading south all over the British Isles and the near continent, as a rather deep, and probably deepening, low pressure system moved southeast or southsoutheast into the North Sea
Pressures in the north of Scotland were generally lowest on the night of 27th - 28th December, when the depression was probably deepest and closet to the southern and southwestern North Sea
The lighthouse keeper at Spurn Head reported that the gale was from about NNW, with rain and sleet at times
The tide level all over the Scottish coast was recorded as exceptionally high
The very sharp fall of temperatures in Britain from +5ºC to +6ºC on the 26th suggests a very rapid transport of colder air from the Artic, at speed which only maintained themselves on the 28th
And as the frequent snow showers reported in Scotland indicate, the wind stream was probably very rough and gusty

Storm Severity Index: 200-300

Storm # 37

Date: 26th – 27th December 1862

Area: North Sea, and English, Scottish and continental coasts

Observations: NW'ly gales were reported in the Clyde and on the east coasts of Scotland, severe gales in some parts and gales from W or SW in the North Sea

Meteorology: Daily Meteorological Office reports show a W'ly situation, gradually turning to NW, over the North Sea
Pressure was low or very low with an anticyclone present

Storm Severity Index: 3000

Storm # 38

Date: 24th January 1868

Area: Scotland and northern North Sea

Observations: S'ly and SW'ly gales were reported from early on the 24th from the southeast and south coasts of Scotland
Parts of stone buildings were blown away all over Scotland, where the wind force was presumably also that of a strong gale or storm

Historic Storms of the North Sea

Meteorology: Evidence of a wintry high pressure situation, with the situation over the British Isles having been generally cyclonic for some days previously
A rapidly sharpening pressure gradient for S'ly and SW'ly winds existing over the northeastern parts of Scotland as warm air pressed in from the Atlantic.
Temperatures on the Atlantic fringe were from 7-11°C
The storm on the 24th was associated with an unusually intense development, presumably with a strong jet stream from about SW in the upper atmosphere, accompanying the long narrow warn sector detected over the British Isles that day

Storm Severity Index: 2500

Storm # 39

Date: 24th March 1878

Area: the British Isle, especially the coast of Scotland

Observations: Reports of gale, and even hard/sever gale, almost confined to sudden squalls

Meteorology: A NW'ly and N'ly wind situation prevailed over the British Isles and parts of the Norwegian Sea and North Sea from 22nd March to the first days of April
This was a very cold Artic stream, which ultimately extended southwards
The Meteorological Offices Daily Weather Report states '... weather was fine over the greater part of the country, but in the north of Scotland ... showers had commenced at 8am ... In the course of the day, a small depression passed south from the north of Scotland along our east coast, causing an extremely sudden change in the weather ... bright clear skies being followed very quickly by heavy snow, while the wind rose to a gale or hard gale ...'

Storm Severity Index: 150

Storm # 40

Date: 28th December 1879

Area: Great Gales reportedly widely all over Scotland The 'Tay Bridge Disaster' storm

Observations: Gales from the S or SW were reported at most points on the Atlantic coasts of the British Isles as early as the morning of the 27th
Severe S'ly gale force 9 was reported that evening.
On the 28th the storm eased during the first half of the day, especially in Scotland where the winds became quite light and generally W'ly for a while
Later in the day the winds returned and freshened rapidly, after dark the wind was squally
In the Firth of Tay, where part of the railway bridge collapsed whilst a train was on it, the winds were WSW and was probably sudden and squalls were occurring roughly ever 10 minutes with the wind at force 10
At the height of the storm people in Scottish towns were scared to leave their house because of the falling trees and masonry

Meteorology: None noted

Storm Severity Index: 4000

Storm # 41

Date: 14th –15th October 1881

Area: The North Sea, most of the British Isles

Observations: Great loss of life at sea and the destruction of shipping, attributed particularly to the suddenness with which the storm came on and the violence of the squalls
A special meeting of the Royal Meteorological Society in 1881 noted '… the area over which injury was produced was very large … the damage was excessive … In Scotland the destruction of trees was enormous …'. The morning of the 14th had dawned fine, with clear skies and a calm sea
In the middle of the day the wind fell light, and then the storm struck suddenly
Inland this gale was considered '…a great storm…' and in many perhaps the '… the severest since 1859 …'
The storm wind was SW on the afternoon of the 14th and turned to WNW in the morning of the 15th

Meteorology: The cyclone centre which produced this storm was first identified about 150 miles south of Nova Scotia on the 10th
By noon on the 13th it had only deepened to 997mb and was in longitude 22°W
It deepened greatly to about 960mb as it crossed the British Isles and reached the North Sea, drawing Artic cold air into it's rear side
The evening of the 14th had a N'ly gale, that morning there had been E'ly gales in northern Scotland with only 6-7°C
At noon on the 14th strong SW'ly gales force 9 were reported by several ships on the central North Sea. ENE force 11 gales were reported in several parts of the east coast of Scotland

Storm Severity Index: 1500

Storm # 42

Date: 6th March 1883

Area: Whole of the North Sea

Observations: Northerly gales were observed across the whole of the eastern coastline of the British Isles
Many lives were lost at sea from several British fishing communities

Meteorology: On 5th March a broad airstream from between W and NW covered the area between the Hebrides and the northern Baltic, on the flank of an anticyclone (central pressure 1043mb) centred over the western part of Ireland

Barometric pressure on the morning of the 5th was falling quickly over the whole region of the NW'ly winds north of Scotland, and later that day over the North Sea.
Temperatures over the British Isles had been normal for the first 5 days of the month, but it then became very cold with frequent severe frosts, snow and hail falling on many days and often strong winds, and so continued like this till the end of the month
Winds from the E and N prevailed during this time, and with a monthly mean temperature of 1.9°C, this ranked as one of the four coldest Marches in over 300 years of records

Storm Severity Index: 1500

Storm # 43

Date: 16th – 20th November 1893

Area: British Isles, North Sea and neighbouring sea and coastal areas

Observations: This storm passed steadily but rather slowly eastwards and gave a very prolonged gale or strong gale in some areas
The severest part was the NW'ly to N'ly gale, the worst effect being reported in northern Ireland and the Scottish North Sea coast

Many trees were blown down in exposed districts, in northern Ireland, southwest Wales, and eastern Scotland, as well as great loss of life at sea

Meteorology: This storm was associated with a deep depression, the centre crossing Ireland at it's deepest stage on the 16th – 17th with heavy rain and sea level pressure down to 965mb
It passed across Scotland and into the North Sea on the 17th
The slow advance of this storm with it's developing belts of S'ly and N'ly winds – the latter well seen over the days from 15th – 18th – was controlled by a slowly marching meridional circulation pattern
The strongest N'ly gradient winds over the Atlantic and later over Britain and the North Sea on the 17th – 19th seem to have been in the region of 90-100 knots

Storm Severity Index: 5000

Storm # 44

Date: 10th – 13th February 1894

Area: The North Sea and surrounding lands

Observations: Strong SW'ly and W'ly gales, ultimately veering to the NW, caused sea floods, with damage inland
In England, Scotland and Ireland this February was noted as a very stormy month with deep depressions passing in rapid succession

Meteorology: The W'ly wind sequence was maintained by cyclone centres mainly in latitudes 60° to 70°N over these days
A secondary depression, giving SW'ly gales up to force 10 in mod-Atlantic near latitude 50°N on the 10th, travelled to a point northwest of Ireland on the morning of the 11th with a central pressure of 975-980mb
In the Artic outbreak from the Norwegian Sea, which developed behind the centre, snow showers spread south over Scotland, created fierce storminess

Storm Severity Index: 2500

Storm # 45

Date: 28th – 29th November 1897

Area: The Whole of the British Isles, later especially the coasts exposed to the North, and the North Sea

Observations: This gales was first felt in western Ireland (Co. Galway) as a stormy W wind on the 27th
The storm increased as it advanced east, and all parts of the British Isles experienced a strong NW'ly gale on the 28th, continuing into the 29th in England, Scotland and Wales, and becoming NNW or N'ly except in the extreme south
The wind was at gale force for 24 hours in many districts and was described as a 'furious gales' but remembered for it's exceptionally high tide that accompanied it, said to be the highest in living memory for many places
There were many shipwrecks around Britain's coastline in this storm

Meteorology: November had been a fine, mild, dry month in the British Isles, especially the southern half
The breakdown of the anticyclonic W'ly wind situation over Britain into a gale which led to the N'ly storm over the Isles and the North Sea on the 29th
Temperatures between 8°C and 12°C prevailed in the surface air over southern parts of the British Isles in the warm sectors coming in from the Atlantic, but very much cooler air lay over the continent in France and Germany
Storm Severity Index: 500

Historic Storms of the North Sea

Storm # 46

Date: 25th – 26th December 1902

Area: Northern and Eastern North Sea

Observations: A severe storm with unusually high winds for the regions concerned, doing great damage to many woodlands
It was also seen to lift roofs, destroy buildings and kill people
The winds during this storm were broadly W'ly but SW at first and finally NW'ly

Meteorology: The first 13 days of December had produced a rather severe cold spell with E'ly winds, followed by S'ly winds in the middles of the month, but W'ly dominated the last part of the month, particularly in the British Isles
On the morning of the 24th December the barometric pressure was very low over the Barents Sea, with a cyclonic centre about 960mb, the end point of a succession of vigorous depressions steered in that direction by a long SW'ly airstream from the western Atlantic near Bermuda and the extensive anticyclonic system from near 30°N and 50°W to the British Isles
The temperatures had not fallen below normal over the British Isles with the approach of the cold air mentioned, and by the 27th – 28th another cyclonic system had arrived from the Atlantic

Storm Severity Index: 2500

Storm # 47

Date: 26th – 27th February 1903

Area: A belt across Ireland, Wales and most of England, especially the North, and Scotland, to the North Sea and Denmark

Observations: The greatest hourly mean wind speeds recorded in this gale were very high (force 11)
There was great damage to buildings and trees, and some cattle were killed, houses were unroofed and there were many disasters at sea

Meteorology: A belt of high pressure from a warm anticyclone centred over the eastern USA near Washington DC (over 1035mb) to another southwest of the Azores (1042mb) to another over North Africa (1031mb) had been keeping a flow of generally mild air right across Europe
A succession of cyclone centres was steered eastwards from the Western Atlantic, finally reaching Europe, bringing cold air from the central Arctic
The gradient wind probably reached over 80 knots in the warm sector SW'ly wind over the British Isles and a similar speed in the S'ly gale, before the fronts over the North Sea
The gradient may have approached 100 knots at the deepest phase of the storm centre on the 27th

Storm Severity Index: 3000

Storm # 48

Date: 12th – 13th March 1906

Area: Whole of the North Sea and its coasts

Observations: On the 12th N'ly winds of force 8 were reported throughout the whole width of the Norwegian Sea, on the eastern and western coasts of Iceland as well as the coastline of Britain
Force 10 winds were reported widely, as were snow and rain
By the night of the 13th it was reported that the storm grew stronger and turned more W'ly

Meteorology: A cyclone centre with lowest pressure about 980mb approached the coast of northwest Ireland from the Atlantic on the morning of the 11th March, as an anticyclone that had dominated southern and central Europe for several days gave way
Very cold air from the Norwegian Sea and Iceland was drawn to its rear side and the cyclone deepened rapidly over the North Sea
On the morning of the 12th barometric pressure were down to below 960mb as the system moved northeast

Storm Severity Index: 3000

Storm # 49

Date: 3rd December 1909

Area: British Isles

Observations: There were many shipwrecks and many lives lost as a very deep depression crossed Ireland over to the British mainland, with central pressure down to 948mb at the deepest phase
Gales force 8 from between WSW and WNW were blowing over much of Scotland and the 3rd and force 10 from these directions was reported over the North Sea and it's British coastline

Meteorology: Pressure had been low over the British Isle - North Sea - Norwegian Sea region for about a week beforehand
On the afternoon of 2nd December and already deep cyclonic centre (below 970mb) approached the west coast of Ireland from the Atlantic
It crossed over to the British Isles during the following night

Storm Severity Index: 2000

Storm # 50

Date: 16 February 1916

Area: The British Isles and the North Sea

Observations: Accounts are rather sparse here as the was inhibited publication at the time
Strong W'ly gales were reported from early on the 176th, and by evening the wind was reported to be force 9-10

Meteorology: Winds over the British Isle-North Sea region were generally W'ly all throughout that winter
On the 15th the main low pressure centre was over Iceland (970mb) – roughly where it had been for three days – and a small secondary depression (lowest pressure about 990mb) derived from a frontal wave disturbance which had formed mid-Atlantic passed over the British Isles and onto Europe
On the 16th a frontal cyclone with a well-marked warm sector over the North Sea and its centre (970mb) near the northeast coast of Scotland

Storm Severity Index: 2500

Storm # 51

Date: 26th – 27th January 1920

Area: Mainly the British Isles, and at times the North Sea

Observations: A S'ly gale, force 8-9 recorded widely over Scotland was reported on the evening of the 26th

Gale force from SW was reached that night also on the coasts of Ireland, and by the morning the same conditions were reported over parts of England
During the 27th the gales was at its most severe over Ireland, Scotland and the west of England, at time becoming particularly violent

Meteorology: The review of this month of January in the *Meteorological Magazine* (Vol. 55 p.11) says that '... weather of a .... South-westerly type prevailed...Depressions, which were often of great size and intensity, followed on another in rapid succession ... Gales were frequent and widespread ...'
This gale of the 27th was the most serious, the cyclone that caused it formed as a wave disturbance on a well-marked Atlantic polar front, and by the 25th was travelling quickly east across the ocean
By midday on the 26th it was centred near 55° N 33 °W, having covered 1600 miles in 24 hours, a speed of nearly 70 knots and having deepened from 1019 to984mb
This had become a very big depression, which dominated the whole Atlantic

Storm Severity Index: 4000

Storm # 52

Date: 28th January 1927

Area: The British Isles and neighbouring seas between the latitudes of 50° and 60° N

Observations: '... Gales in some districts of exceptional violence ...' was reported in the *Monthly Weather Report* of the Meteorological Office
There was '... considerable structural damage, involving loss of human life in some cases ...' many of the deaths through buildings being blown down
Fishing boats were swamped by the seas and dashed on many coasts
The storm wind came on quite suddenly and passed quite quickly across the British Isles, the duration of the gale force winds being between 3 – 4 hours

Meteorology: As in the previous winter, there was a great predominance of W'ly and SW'ly winds over Britain and northern Europe with a continual succession of depressions often of great size and considerable intensity
Two days before the storm struck the UK a remarkable thermal contrast was built up in a frontogenetic and cyclogenetic situation over the western Atlantic
Cold air brought swiftly from northern Canada by strong W to NW winds was still producing surface temperatures as low as -2°C a hundred miles or more out into the Atlantic
The depression forming in that area deepened from 1014 to about 990mb as it moved towards mid-Atlantic, where for some time on the 27th the pattern became more complex, with two low pressure systems
By the 28th however, this had been reduced to a single intense cyclone with central pressure about 950mb and one main front approaching the British Isles, with squally winds widely reported as force 7-10 from about SW veering W
The strongest gradient wind indicated seems to be about 75 knots

Storm Severity Index: 2500

Storm # 53

Date: 6th – 7th January 1928

Area: North Sea

Observations: This was a brief, though severe, NW'ly gale the rear side of a fast moving storm depression
The cyclone centre, which had appeared as an open wave on the main Atlantic cold front on 5th January (lowest pressure 1009mb)
This gale following the cold front was preceded by 6-9 hours of rising SW-W winds

A storm surge was built up by the NW'ly wind in the North Sea raising the height of the tide about 50cm above expectation, some serious flooding occurred all around the British Isles
Though this storm passed quickly it came in the midst of a very stormy sequence

Meteorology: With the gradual disappearance eastwards of the blocking anticyclone over continental Europe, where the front gave way to westerly winds, vigorous Atlantic depressions advanced eastwards in quick successions
The sequence was remarkable for the speed of travel of these occluding depressions and the brevity of the interval between each major depression and the next
Another noteworthy feature was the high temperatures prevailing over the Atlantic and Europe's Atlantic coasts as far north as Stornoway
Air temperatures were reported to be +13°C to +14°C, reported by ships in the North Sea, which points to abnormally high sea temperatures

Storm Severity Index: 1600

Storm # 54

Date: 17th – 19th October 1936

Area: The British Isles, the North Sea and its coasts

Observations: Strong W'ly gales force 8-10 about the northern coasts of Scotland from midday on the 17th spread to the west coast of south Norway by that evening
On the morning of the 18th the gale had more or less ceased in Britain, but by the afternoon/early evening force 8-9 prevailed all over the UK, from N and NW

Meteorology: This gale was caused by a deep cyclone which developed from a frontal wave (approx. 993mb) in an almost classically frontogenetic and cyclogenetic situation
The system deepened rapidly to 965mb as it moved about 900 miles to a position just north of Shetland on the evening of the 17th
The strongest gradient winds measured in this storm seem to have been about 70-75 knots potentially reaching 80-90 knots in some places

Storm Severity Index: 1200

Storm # 55

Date: 26th – 27th October 1936

Area: The British Isles, North Sea and its coasts

Observations: This development somewhat resembled that of the previous storm nine days earlier, but this one was a more severe gale
Gusts of over 90 knots were reported
The SSW wind, force 10, freshened to gale force in the evening of the 26th
There were several sea floods reported all around the coastlines of the North Sea, with some up to 4.5m higher than normal

Meteorology: The depression which brought this storm developed form a small Low centre (1009mb) on an open wave on the main Atlantic front near Newfoundland on the 25th
This feature crossed the Atlantic very quickly, covering 1500 miles in 24 hours (62 knots) to a position west of the Hebrides (974mb) on the 26th
It then moved southeast to affect the eastern coastline of Scotland before moving slowly to Norway by the 27th

Storm Severity Index: 2000

Storm # 56

Date: 10th – 13th February 1938

Area: The North Sea

Observations: This is a case of a N'ly gale which developed almost simultaneously over the whole width of the North Sea
On the 11th the N'ly wind stream, with reports of force 7-8 on some coasts, extended all the way across the North Sea
Force 9 was reported briefly in some places

Meteorology: A cyclone centre near 70°N 10°E on the morning of the 10th moved off southeast
Warm air streaming over the UK from W to NW on the 10th was soon limited to an occluding warm sector that passed south
The N'ly winds over the North Sea became less strong over the northern North Sea, where on the 13th gale force only occurred either in squally showers or in regions with local convergence effects

Storm Severity Index: 500

Storm # 57

Date: 1st – 2nd June 1938

Area: The British Isles

Observations: This summer gale in the night of the 1st - 2nd June was described by the *Monthly Weather Report* of the Meteorological Office as attaining '… a violence unprecedented for the time of the year since systematic wind measurement began …'
Gusts of upto 76.4 knots were measured
This gale was described in the *Meteorological Magazine* (1938, Vol. 73, pp.139-42) as the '… climax of three very disturbed days, at a season when the average gale frequency is at about its minimum …'

Meteorology: A small but intense, depression moved about 600 miles in the 24 hours by the 1st June across the UK into the North Sea where it lingered on the 2nd – 3rd while filling up
There were gales near its centre, S'ly force 8
The intense development in late spring/early summer clearly owed its occurrence to the unusual temperature contrasts existing
The winds reaching Scotland from the north were so cold that snow covered the low ground
Meanwhile very warm air was flowing S and SW in the warm sector over the UK as well, temperatures reaching 26°C

Storm Severity Index: 150

Storm # 58

Date: 23rd – 24th November 1938

Area: The British Isle, the North Sea and its coasts

Observations: Severe gales reported over Ireland, England and most of Scotland on the 23rd and later on in the North Sea
Force 11 from WSW or SW was recorded at several points on the North Sea coasts

Meteorology: The frontal cyclone which caused these gales had appeared as an open warm sector near 50ºN 28ºW (993mb) in mid-Atlantic on the 22nd but was already drawing into its rear very cold air from Greenland and Davis Strait
It deepened rapidly across the British Isles as a 960mb centre on the 23rd, when temperatures as low as -2ºC to -4ºC were observed in the mid-Atlantic

Storm Severity Index: 2500

Storm # 59

Date: 14th – 19th December 1938

Area: Affecting the whole of the North Sea and its associated countries

Observations: Many reports of severe shipping difficulties
The situation ended on this occasion with continental cold air and frost spreading over western Europe and the British Isles

Meteorology: In this case the advancing front of mild Atlantic air and cyclonic activity impelling it were brought to a halt as the anticyclone over northern European Russia and western Siberia intensified, its central pressure reaching 1065mb, and causing cold fronts to advance over the North Sea and later the British Isles

Storm Severity Index: 2000

Storm # 60

Date: 9th – 10th February 1949

Area: The British Isles

Observations: A W'ly gale force 9 was first reported on the morning of the 9th, and force 7-9 was widely reported all over later that day
The winds over the North Sea veered NW to NNW overnight and a '… powerful storm …' was reported bringing in a storm flood tide

Meteorology: This cannot rank as a very severe storm, but the sea flood threat was very serious
The very high water levels must be attributable to the long duration of stormy W'ly winds over the Atlantic, with the collapse of a large blocking anticyclone frost situation dominating
A small secondary low pressure centre (lowest pressure 990-995mb) formed in the early hours of the 9th, deepening rapidly later on that night
The winds had eased by the 10th

Storm Severity Index: 250

Storm # 61

Date: 23rd – 26th October 1949

Area: The British Isles, the North Sea and the Baltic

Observations: Gales form the SW, and later N or NW in most parts of the British Isles and North Sea
There was a renewal of gale force winds (upto for 9) from SSW over the southern and eastern North Sea on the morning of the 26th, veering N by the end of the day
The gale on the 23rd caused considerable damage to may sea defences
The highest wind speeds reported in Britain were 74 knots

On the 25th the Bell Rock Lighthouse in the North Sea, east of Dundee, reported gusts of 68 knots, presumably from the N or NE

Meteorology: This series of gales was caused by two main storm cyclones which crossed the North Sea on the 24th and 26th
A small secondary low pressure centre on a frontal wave at 48°N 25°W on the 22nd moved quickly northeast, covering over 700 nautical miles 24 hours later
It was this feature that produced the damaging winds on the 23rd
The strongest gradient winds measured in these systems seem to have been no more than about 70 knots
The heights reached by the storm tides and the damage done must be largely attributed to excess water driven into the European coastal sea by the long spell of strong W'ly winds over the Atlantic

Storm Severity Index: 250

Storm # 62

Date: 30th December 1951

Area: Northern and eastern Scotland and northern Ireland, and neighbouring seas

Observations: Violet gale caused extensive and widespread damage, also some flooding in coastal districts
The *Weather* reported it as '… considered the most extensive and severe gale in Scotland since 1927…'
Several deaths were caused
The strongest gusts reported were 94 knots at Millport, 87 at the Bell Rock Lighthouse

Meteorology: There were several gales affecting the British Isles during the last five days of December 1951, this one on the 30th being the severest
A series of deep depressions approached the British Isles, crossing the Atlantic on eastnortheast or northeastward tracks from a zone off the American seaboard
At least two of the storm cyclones over the central to eastern Atlantic during those days – the 26th and 30th – were characterised by somewhat unusual, strong deepening of the occluded system, leading to very strong pressure gradients close to, and nearly all around, the centre
There were strong thermal contrasts between the main airstreams feeding into the cyclone, as is usual in intense systems in these latitude

Storm Severity Index: 2000

Storm # 63

Date: 17th December 1952

Area: Scotland and northern and eastern England, with nearly all parts of the North Sea

Observations: Severe NW'ly and N'ly gale
Strongest gusts recorded at 96.4 knots

Meteorology: The depression in the North Sea on the 17th was very deep (below 960mb) when it passed over northeastern Scotland
The system travelled southeast at about 27 knots
The strongest gales developed over Britain as the Low moved southeast over the North Sea
By the 18th a W'ly wind pattern was established over the British Isles and lasted for over a week
It was, however, mainly a cold month with blocking patterns on most of the other days
In the afternoon of the 17th winds of gale force 8 from the N or NW were reported at many British coastal stations Geostrophic winds up to 100 knots and gradient winds up to 74 knots are indicated over central and eastern Britain

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Historic Storms of the North Sea

Storm # 64

Date: 31st January – February 1953

Area: The North Sea, the whole of the east coast of Scotland where the severest effects were felt

Observations: Great sea folds were reported in many coastal locations, where the tidal surge raised by the storm peaked within a couple of hours of the predicted high spring tide about midnight of the 31st – 1st and altogether about 2000 people were drowned by the sea floods
There was also great damage to forests in Scotland
Winds of force 10 from NW to NNW were reported on the most exposed parts of the British coast, both in England and Scotland
Gusts between 93 knots and 109 knots were recorded in various parts of Scotland

Meteorology: The strong winds over the North Sea region on these dates developed in the cold air from the Artic – a direct northerly airstream reaching Shetland – at the rear side of a depression
At the same time an anticyclone was building up over the Atlantic and extending in a north-south orientation

Storm Severity Index: 6000

Storm # 65

Date: 21st – 23rd December 1954

Area: The North Sea, Scotland

Observations: Two storms affected the named region, one on the 21st and one on the 23rd December
On the 21st W to NW winds of force 9 and 10 were 13040300750orted at many places, chiefly in Scotland
Gusts of between 60 and 70 knots occurred widely
The storm on the 23rd followed a similar path and pattern, notable gust strengths reported being 75 knots
Beaufort force 10, 11 and 12 being noted on the afternoon of the 23rd
The sea reached flood levels in the storm of the 23rd

Meteorology: These gales, and the severe squalls accompanying the cold fronts, and the cold air breakouts at the rear of two depressions, occurred to the right of the path of the centres of the depressions, which were being steered by a NW'ly jet stream
The thermal contrast was great between the warm air reaching the mid-Atlantic and forming warm sectors passing over or near to the British Isles and the Artic air predominating over the region, which was drawn from both sides of Greenland and northern Canada
R. Murray and C.P.W. Marshall published a note ('The Storms and Associated Surges of December 21-23, 1954', *The Meteorological Magazine*, 1955, Vol. 84, pp. 333-341) reporting these two NW'ly storms over the North Sea which produced severe squalls and considerable storm surges, the highest up to that date since the storm of 31st January – 1st February 1953
There was no specific coastal flooding as the storm did not coincide with the spring tides

Storm Severity Index: 1000

Storm # 66

Date: 16th – 17th February 1962

Area: North Sea and its neighbouring lands

Observations: Winds of strong gale force, force 9, from the SE were observed already at midday on the 15th February

Twenty-four hours later force 10 or 11 was observed in a widespread NW'ly storm from northern Scotland and the Hebrides, to Denmark
At the following midnight WNW or NW for 9 to 10 was occurring widely from all over Scotland to central North Sea and the islands of the coast of Sweden
There was widespread storm damage all over Britain on the 16th

Meteorology: The gale was produced by a deep depression which had approached from the west, central pressure 959-960mb in two centres on the 16th when the W winds in the wide warm sector were reaching gale force over two-thirds of the North Sea
The outbreak of NW to N winds which covered the North Sea on the 17th, **after the cold front has crossed the area during the previous day, ended a long sequence of westerly winds over the British Isles and North Sea which has started on 30th January**
The prolonged spell of strong westerly winds in latitudes is considered to have built up the water level in the North Sea to higher than normal before the additional surge impelled by the NW and N winds which followed this depression

Storm Severity Index: 4000

Storm # 67

Date: 6th March 1967

Area: All Scotland, and later the Norway coast

Observations: **First reports of force 9 SW'ly came from the coasts of Ireland on the 6th**
The gale then swept across the whole of Scotland, producing gusts of 79 knots in several places

Meteorology: A great current of SW'ly winds was maintained from mid-Atlantic over a period of **many days, by a series of Lows moving northeast and passing between Scotland and Iceland, through the Norwegian Sea to the Barents Sea**
Meanwhile cold Artic air was streaming south
The strongest gradient winds measured over the British Isles and the northern North Sea were from about 72 to 85 knots around midday on the 6th March, from about WSW to W
The duration of the winds of damaging strength, force 10 or above, seems to have been no more than a few hours
The width of the stream winds of damaging winds across Scotland and the North Sea at the height of the storm was about 100-120 sea miles and its length only about 300

Storm Severity Index: 50

Storm # 68

Date: 14th – 15th January 1968

Area: The whole of Scotland and northern England

Observations: A SW'ly gale was reported on the 14th, with gust of 89 and up to 102 knots recorded at various places

Meteorology: This gale was a feature of a westerly sequence, lasting about a week, with the depression mainly in a belt about 58° to 63°N
Vigorous secondary Lows developing from waves on a trailing cold front between the Azores region and the North Sea, being ultimately absorbed into and supplying energy to the main system
Gradient winds up to about 140 knots probably affected a limited area near the depression centre over the Atlantic on the 14th, and later were slightly over 100 knots in the W'ly cold airstream across Scotland and the North Sea
The greatest duration of winds of damaging strength at any one place lasted only about 4-5 hours
The width of the zone of damaging winds was only about 100 sea miles over a length of 250 to 300

Historic Storms of the North Sea

Storm Severity Index: 150

Storm # 69

Date: 7th February 1969

Area: The British Isles and the North Sea, especially the northern North Sea and it's associated coastline's

Observations: The 7th February saw a gust of 118 knots '... the second highest wind speed ever recorded on the British Isles... ' was measured by the Meteorological Office

Meteorology: This was an incident in a N'ly gale bringing direct Artic air from the polar basin south over the British Isles behind the cold front of a depression which travelled slowly southeast from east of Iceland on the 6th
Very strong pressure gradient existed on the 6th within the ambit of this depression, particularly west and north of the centre, in the form of a long sweep of strong N'ly winds bringing exceptionally cold air rapidly south through the Fram Strait between Greenland and Spitsbergen from near the North Pole
The Artic airstream spread south over the British Isles during the 7th
Temperatures fell below freezing point that evening, with the strong wind lifting frozen snow from the streets
Most roads were blocked by drifted snow and strewn with hundreds of abandoned vehicles

Storm Severity Index: 300

Storm # 70

Date: 4th – 5th December 1979

Area: Coasts of Norway, also coasts of northern Scotland

Observations: Hurricane force winds from SW, and later W, produced a sea flood (storm surge up to 1.2m above the predicted tide) in the night of the 4-5th December, washing over the quays, washing away barns in coastal fields, and causing millions of pounds worth of damage
Gusts of up to 111 knots were also recorded

Meteorology: The storm developed from an open wave disturbance seen on the polar front near 47°N 40°W at noon on the 3rd
The air mass thermal contrast in that region was strong between maritime tropical air giving temperatures of 16°C in the warm sector and Canadian cold air with surface air temperatures close to the freezing point
The disturbance travelled 1200 miles in the next 24 hours (50 knots) steered by the jetstream giving observed winds up to 100 knots as low as the 5kn level
The central pressure fell to about 959mb in this time

Storm Severity Index: 4000

Storm # 71

Date: 23rd – 25th December 1981

Area: The whole of the North Sea

Observations: NW'ly winds of 50 knots were reported in the northwestern sector of the North Sea from the evening of the 23rd
By the 24th 50 and 60 knot winds were reported from NW and the W

Historic Storms of the North Sea

Sea levels rose by 5.02m above the expected tide in some places

Meteorology: The slow and steady development of the situation meant that the prospect of a severe NW'ly storm began to be apparent 3-4 days beforehand, as the depression centre approached Shetland from Iceland with sharpening of the air mass contrast between the mild, humid air at that time over Britain, Denmark and Germany and Artic cold air being drawn south over Iceland
The cyclone centre near Shetland had deepened to 963mb by the 23rd and maintained about that same depth as it was transferred across southern Scandinavia to the Baltic on the 25th
Geostrophic wind strength approached or exceeded 100 knots over all parts of the North Sea area

Storm Severity Index: 6000

Storm # 72

Date: 1st February 1983

Area: All of the North and its coasts, Britain in particular as well as parts of the continental coast

Observations: Exceptionally high tides levels occurred on the coast of England, up to 6m above normal causing sea floods in many coastal areas
No lives were lost

Meteorology: This gale system, which produced storm force winds, particularly the W'ly to NW'ly winds on it's southern side, but also at some stage an E'ly storm, and a N'ly storm over and near the coast of Scotland, was associated with a depression which crossed the Atlantic on an eastnortheastward track, deepening steadily
It passed across Scotland, its central pressure 950mb as it reached the North Sea, it was then steered E to S, to cross central Jutland and the Danish Islands into the Baltic
The gradient winds were about 100 knots over the North Sea as the centre of depression passed over
At midday on the 1st, winds of force 9 and 10 were reported extensively

Storm Severity Index: 1500

Storm # 73

Date: 3rd – 4th March 1988

Area: Northern North Sea and the east coast of Britain

Observations: A N'ly storm

Meteorology: The long track N'ly outbreak from the high Artic to the North Sea developed behind a cyclone that had moved from the western Atlantic to the Denmark Strait between Greenland and northwest Iceland, where it showed a 1002mb centre on the 1st
It then moved steadily, but slowly, southeast
The strongest N to NNE gradient winds over the northern North Sea on the 3rd - 4th seem to have been in the range of 70 – 75 knots
The violent action of the sea must be related to the long fetch over open water of the strong wind which persisted from midday on the 2nd

Storm Severity Index: 200

Storm # 74

Date: 21st – 22nd December 1988 and mid-January 1989

Area: The Northern North Sea and its coastlines

Observations: Strong W'ly storm associated with a frontal wave depression that had come up from the southwest
Mean wind speeds up to 82 knots were measured, although gusts of 112 were also recorded
Damage to buildings

Meteorology: The central pressure of the cyclone reached 940 – 945mb

Storm Severity Index: None noted

Storm # 75

Date: 13th February 1989

Area: Scotland and neighbouring sea areas

Observations: Violent W'ly and NW'ly gale caused widespread damage on land and sea
Large building were un-roofed
The strongest gusts of wind were recorded at 126 knots

Meteorology: A cyclone which had advanced 1500 miles (995mb) in about 24 hours, reached Scottish waters in the afternoon of the 13th and turned eastsoutheast
It had been driven by Artic cold air south with temperatures as low as 1°C
A very strong pressure gradient developed near the back occlusion coiled round on the western side of the low pressure centre
This was an incident in a long and very disturbed Atlantic cyclonic sequence which produced another, deeper centre (below 960mb) again between Scotland and Iceland on the 14th

Storm Severity Index: 800

Storm # 76

Date: 16th – 17th December 1989

Area: British Isles and surrounding seas, Bay of Biscay and especially the northern North Sea

Observations: Very strong gales, mainly S'ly and SW'ly but E or NE over northern Scotland
Gusts to 104 knots were recorded along with very heavy seas breaking over onto the land
At least nine lives were lost in Britain, mainly at sea and with people being washed into the sea

Meteorology: A very deep, already largely occluded, cyclone, which had been centred at 935mb at midday on the 16th and had been moving northeast towards the British Isles during the b15th, arrived at the south coast of Ireland on the 17th and preceded to cross Ireland into Scotland by that evening

Storm Severity Index: None noted
