VULNERABILITY TO A NATURAL HAZARD: GEOMORPHIC, TECHNOLOGICAL AND SOCIAL CHANGE AT CHISWELL, DORSET

by

James Lewis
Centre for Development Studies
School of Humanities and Social Science
University of Bath

December, 1979

Working Paper 37

Vulnerability to a Natural Hazard: Geomorphic, Technological and Social Change at Chiswell, Dorset

The community of Chiswell has enjoyed a hitherto advantageous proximity to the sea, and protection from all but extreme sea hazard, for more than a thousand years. Two recent disastrous events during one winter have raised doubts concerning the degree of continuing protection afforded by Chesil Beach.

Apparently, static physical conditions of the protecting beach are subject to geomorphic change which has increased the vulnerability of the community. At the same time, technological changes, taken with regard to sea hazard or not, have exacerbated vulnerability for the community. Programmes for community "improvement" have been implemented without due regard to sea and flood hazard.

Social adjustments to the hazard have to be taken as a matter of first priority in the assessment of the cost-effectiveness of technological measures, and integration in social administration of all adjustments to hazard must be a matter for policy formulation.

TABLE OF CONTENTS

Preface vi

Acknowledgements. vii

Introduction. 1

Geomorphic Change 3

Vulnerability and Its Consequences. 8

Flood and Storm 12

Technological Change. 14

Social Change 17

Conclusion. 27

Bibliography. 31

Appendix A
A Chronology of Storm and Flood at Chiswell, Dorset 33

LIST OF FIGURES

FIGURE

1 Chiswell, Dorset 2

PREFACE

This paper is one in a series on research in progress in the field of human adjustments to natural hazards. It is intended that these papers be used as working documents by those directly involved in hazard research, as well as inform a larger circle of interested persons. The series was started with funds from the National Science Foundation to the University of Colorado and Clark University, but it is now on a self-supporting basis. Authorship of the papers is not necessarily confined to those working at these institutions.

Further information about the research program is available from the following:

Gilbert F. White
Institute of Behavioral Science #6
University of Colorado
Boulder, CO 80309

Robert W. Kates
Graduate School of Geography
Clark University
Worcester, MA 01610

Ian Burton
Institute for Environmental Studies
University of Toronto
Toronto, Canada M5S 1A4

Requests for copies of these papers and correspondence relating directly thereto should be addressed to Boulder. In order to defray production costs, there is a charge of $2.00 per publication on a subscription basis, or $3.50 per copy when ordered singly.

ACKNOWLEDGEMENTS

The author wishes to acknowledge, with thanks, the involvement of the following in the preparation of this paper: Mr. K. G. Anderson of the Wessex Water Authority; Mr. Stuart Morris of Weston, Portland; and Mr. Rhys Davey, Chairman, Chiswell Residents' Action Group.

Special thanks are due to Dr. A. P. Carr of The Institute of Oceanographic Sciences for his comments on a draft version of the paper.

INTRODUCTION

Physical permanence of a community cannot be assumed in a changing environmental condition. Vulnerability to the sea has increased during the thousand years of Chiswell's existence, and is continuing to do so. Understanding of this changing state by various groups in society is the key to the selection and effectiveness of interacting social and technological adjustments, whether undertaken specifically against hazard or not.

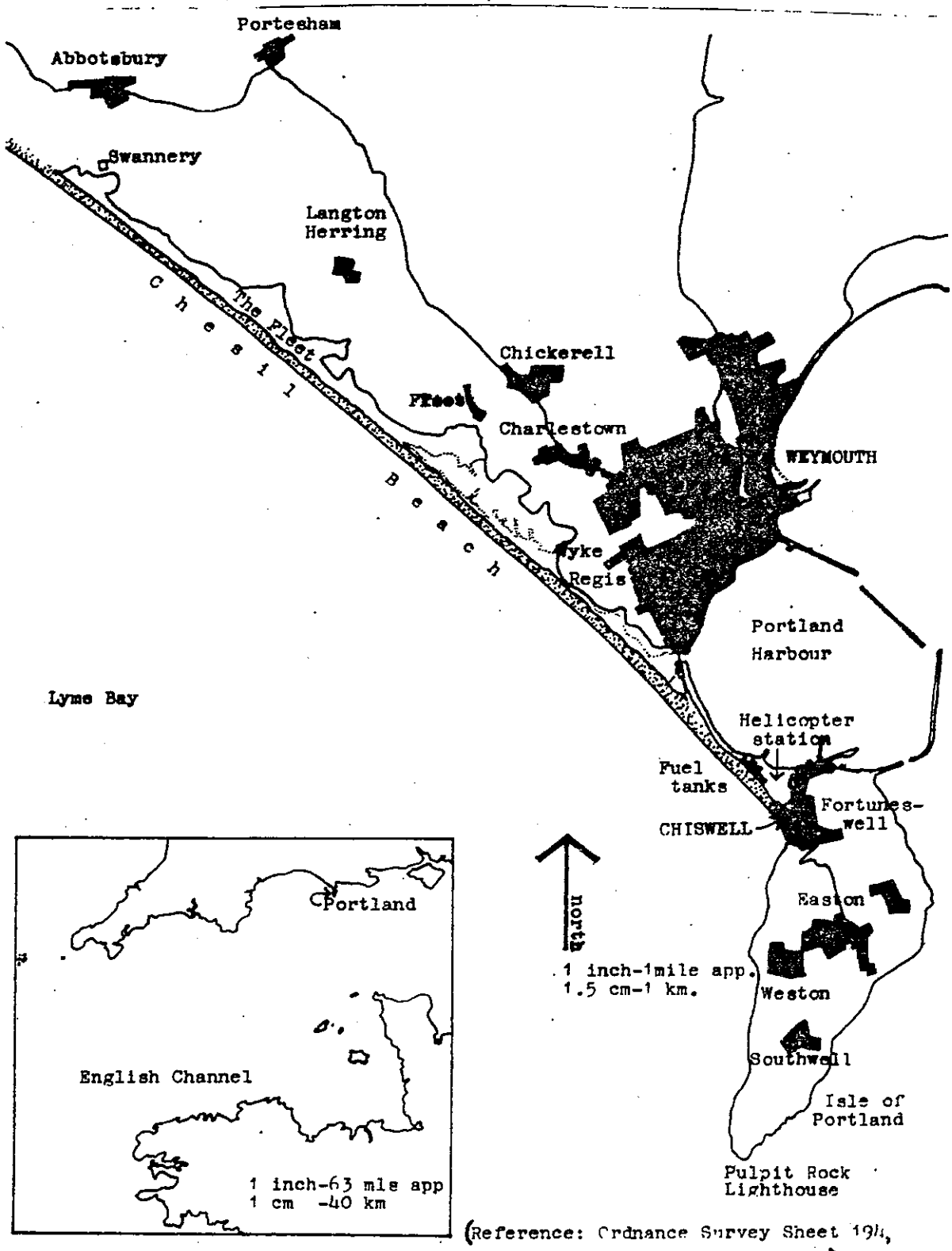
The extent to which technology can effectively ensure prolonged community permanence may only be assessed by detailed analysis of environmental phenomena on the one hand, and by comparison with social adjustments on the other. However, social adjustments cannot be compared until those options are made realistically available by the authorities elected for their administration.

The condition of vulnerability is not static. Analysis and assessment of short and longer-term issues depend on information from the physical and earth sciences, social sciences, and from political and administrative activities. These sciences and processes are themselves not static; that all are in short and long-term processes of change must be understood.

Chiswell, a community of 134 people, is situated at the foot of the north-western slope of the so-called Isle of Portland, off Weymouth, in Dorset; it is adjacent to, but below, the much larger village of Fortuneswell (see Figure 1). Portland is an island but for the shingle bar, or tombolo, and causeway which link it to the mainland. The shingle bar, Chesil Beach, extends for ten miles along the coast of Lyme Bay from a point by Abbotsbury in the northwest

FIGURE 1

CHISWELL AREA



(Reference: Ordnance Survey Sheet 194, 1974)

to Chiswell itself to the south-east. For eight miles of its total length Chesil Beach encloses a lagoon, called the Fleet, between it and the mainland. For the remaining two miles at the south-east end, the sea is on both sides, Lyme Bay on the one and Portland Harbour on the other. Where the shingle bar joins the Isle of Portland and forms a brief trough between the north-west slope of the Isle and the crest of the shingle Chiswell community is located.

Flooding by sea water seepage through the shingle, and by sea waves overtopping the shingle bank is frequent in Chiswell. In December, 1978 and in February, 1979 waves overtopped the bank with such force that several buildings were damaged, and in February the causeway road serving the whole of Portland was breached. Were these freak incidents, and if so, can they be discounted by the authorities responsible for protection and relief? Or, as is suggested locally, do these events signify decreasing protection for Chiswell afforded by Chesil Beach? Is adjustment required in local authority and national government policies for relief, preparedness and preventive strategy?

GEOMORPHIC CHANGE

Chesil Beach has been described as "the most impressive of the three major shingle structures along the coast of the British Isles." As such "it has attracted the attention of travellers, topographers, and research scientists for more than four centuries, since John Leland in 1546." Since then many have sought to discover its origins, but "even now some aspects of the beach's evolution remain obscure" (Carr, 1978).

That this evolution is, naturally, continuing is not only the subject of a number of the papers devoted to Chesil Beach, but is also the basis of local concern regarding the vulnerability of Chiswell community to flooding and wave damage (Chiswell Residents' Action Group, 1979a). Evolution of the shingle bank, relative to the communities to which it affords protection from the sea, may indicate consequent change in vulnerability of established communities to sea and flood hazard.

Being joined to mainland at both ends, the shingle structure is backed by the shallow, tidal Fleet Lagoon for eight miles. The Fleet varies in width from 100 yards to three-quarters of a mile, and in depth from less than a foot to nearly ten feet. Chesil Beach itself is between 150 and 200 yards wide, but is narrower both adjacent to the cliffs in the north-west and at the extreme south-eastern end also. The ridge of the beach progressively increases in height from the north-west to the south-east, the maximum of 45 feet above mean sea level being found adjacent to Chiswell (Carr, 1978).

Comparisons between a survey of Chesil Beach made by Sir John Coode, the site engineer during the construction of Portland Harbour in 1853, and cross-sections made in 1967-69 suggest that, at the north-western end, the shingle bank has increased in height by an average of about six feet during the intervening period. Over the central area, from Langton Herring to Wyke Regis, the increase in height has been approximately five-and-a-half feet. At the south-east end, adjacent to Chiswell, there has been a reduction in the height of the shingle of up to eight feet during the 116-year period (Carr and Blackley, 1978).

The earliest published reference to Chesil Beach is contained in the accounts of Leland's travels of 1535-43, but the earliest detailed

description was by Smeaton in 1803. Scientific analysis in its earliest form commenced 176 years ago, whereas there was probably a fore-runner of the beach 80,000 years ago and Chesil Beach analogous to its present formation from 6,000 years ago (Carr, 1978). One or two hundred years is an iota of the several thousand years during which the bank formed offshore and eventually overrode existing shore line sediments in its inexorable mainland recession.

In a discussion of magnitude and frequency of forces in geomorphic processes and the formation of beach features, Wolman and Miller (1960) refer to the "equilibrium profile" which must be considered as an average form around which "rapid" fluctuations occur. Storm waves may periodically destroy the equilibrium form, but over a period of years there is an average equilibrium profile by which the beach may be characterised. Furthermore, the equilibrium profile is maintained by frequent events of small magnitude which will encourage reversion to equilibrium profile after an event of extreme magnitude has caused sudden change. The question remains, however, of how the equilibrium profile is to be identified at any particular point in time, or how reliable measurements are to be recorded at a number of points in time outside a lifetime span.

Vulnerability to storm and flood at any settlement there has been at Chiswell was increased by short-term changes as well as long-term evolution, a process which is continuing. In seeking to assess the vulnerability of Chiswell to overtopping waves, it is necessary to be able to recognise the "frequent events of small magnitude" and to know how often to expect the rarer events of extreme magnitude. The rare damaging event, which may severely reduce the ridge height of Chesil

Beach, may increase the vulnerability of the Chiswell community to the next frequent event of "small" magnitude. Even though subsequent "small" magnitude events will help to put it back again, it is of little comfort to people to know that within several generations everything will be as it was before they died or lost their homes.

After the beach crest was destroyed by the winter storms of 1978/79, the Local Authority undertook to reform the crest by bulldozing pebble material back into place. This undertaking was financially grant-aided by central government, but how can the integration of this action into the geomorphic cycle of events be assured, and therefore, how can the undertaking, with any certainty, be more than a temporary palliative?

Most writers are in agreement that there has been lateral movement of the shingle bank. One opinion based on comparison of maps produced from surveys of 1880 and 1928, is that the shingle bank has been driven as much as 90 feet to the north-east--that is towards the parallel mainland (Williams, 1960).

As well as shoreward movement there is some longshore movement along the line of the shingle bank. This movement is accompanied by sorting of shingle size. Larger stones are found at the south-eastern end where porosity is greatest. Vertical and lateral movement of the bank is probably accompanied by attrition, a very gradual change within the shingle material itself (Carr and Blackley, 1974).

An examination of conclusions regarding vertical, lateral and integral movement of and within Chesil Bank reveals conditions of long-term evolution, not long-term stability. Most writers are agreed that there is little new material being added to the beach and Williams (1960) vividly describes a possible process:

> If there is no nourishment (arrival of new material) of a shingle feature it must be reduced in size because there must be a gradual reduction in the size of the constituent particles. . . .There appears to be evidence that shrinkage is taking place, and no evidence of the opposite kind has so far been produced. . . .It is interesting to speculate upon the future of this bank; it is being slowly driven towards the mainland, and as it wastes and shrinks it will be more frequently overtopped by storm waves. Chesil Bank appears to have reached a critical stage in its life.

Carr, however, has given the general view, based on evidence, that attrition in Chesil Beach is negligible (Carr and Gleason, 1972), in which case attrition is not a significant contributor to vulnerability at Chiswell. The direct approach of more frequent waves is the most likely cause of some landward movement of the Beach, especially the weakly supported section adjacent to Portland Harbour (Carr and Blackley, 1974) and near to Chiswell. The shingle formation is narrower at both the Abbotsbury and Portland ends, implying less resistance to the direct wave impact, and greater porosity. Where the crest of the beach was higher in 1852, adjacent to Chiswell, it was at that time narrower (Carr and Gleason, 1972); possibly a reason for subsequent reduction by direct and more frequent wave action.

Recession has increased the vulnerability of Chiswell, and especially the causeway at Portland Harbour. The most significant factor of vulnerability, at Chiswell, is the reduced height of the beach crest. The beach crest is now nearer to Chiswell than it was when village settlement commenced. Vulnerability of Chiswell to the sea overtopping the beach, and to seepage, has therefore increased over time.

VULNERABILITY AND ITS CONSEQUENCES

The mainland beyond the Fleet rises moderately steeply and the massive volume of Chesil Beach affords some protection to the inner coastline. Nevertheless, protection afforded by Chesil Beach is probably more directly appreciated in the communities of Fleet, and parts of Charlestown and Wyke Regis. In the great storm of 1824, the church at Fleet, three-quarters of a mile inland from the sea-line of Chesil Beach, was destroyed with several houses but no lives were lost. By contrast, in Chiswell, five miles to the south-east, "upwards of 80 houses" were damaged or destroyed and 26 people died (see Appendix A). Most of Fortuneswell, on the Isle of Portland, is between 100 and 150 feet above sea level, but Chiswell in the third of a mile between the north-west slope of Portland and Chesil Beach, is between ten and 15 feet above mean sea level, and below the 45-foot ridge of Chesil Beach. When waves overtop the ridge elsewhere in its ten-mile length, water runs into the Fleet and eventually to the sea at Portland Harbour. When they overtop at Chiswell, they wash immediately upon habitation.

Chiswell's unique location in respect of its direct vulnerability to sea overtopping and seepage through the Chesil Beach is matched by advantageous proximity to the sea for fishermen. Chiswell is the only community on the Isle of Portland with this close proximity, a practical advantage recognised probably since Roman times. A settlement at Chiswell was recorded in AD 501 (the name Chesil, or Chiswell, is derived from the Saxon for "pebbles") and again in AD 787 when the same settlement was ravaged by Danish invaders (Morris, n.d.). Chiswell was

most probably established as a fishing community, becoming the principal source of fish for the inhabitants of the island.

As a principal community on the island, the population and number of dwellings in Chiswell can be assumed to have expanded throughout the nineteenth century, as did the population of Portland as a whole, due to the prosperity of the quarrying industry for Portland stone and employment on the construction of Portland Harbour. The population of Portland reached a peak in 1901 of 15,199 (Bettey, 1970), after which there was a decline to 12,019 in 1931 (HMSO, 1933), a reduction of 21%. Since 1931, however, there has been a gradual increase in the population of Portland, to around 12,500 in 1970 (Bettey, 1970) which has not been reflected in Chiswell. In 1939 there were 33 commercial premises listed in Chiswell (Kelley's Directories, 1939) including six public houses or hotels; in 1979 there are 11, including only three hotels or public houses.

The present population of Chiswell of approximately 134 occupies approximately 70 dwellings, but in the great storm of 1824 a total of "upwards of 80" houses were "damaged or washed down" (see Appendix A), and in the storm of 1942 100 houses were reported damaged (Western Gazette, 1942). Chiswell does not appear as a separate count on census records and, it is not possible to determine what proportion of the whole community these figures of damage represent, but Chiswell was only recently very much larger than it is today.

Before attempting to assess the role played by natural hazard in this decline, there are two other factors to consider. Close proximity of Chiswell to major naval, and minor civil, south coast ports created considerable vulnerability to damage by enemy air action between 1939

and 1945. Weymouth was severely damaged, and although there are no readily available records of similar damage in Chiswell, it is reasonable to assume that some war damage occurred. A document prepared by Dorset County Council in the 1960's (1964) summarised and quoted earlier reports on post-war planning for Chiswell from 1946 and stated ". . .the area between Chesil Beach and Chiswell Street should be zoned for building development on accepted sea-side lines, and that reconditioning, or rebuilding of derelict or extensively war-damaged properties, should not be permitted." Most of these and other existing properties were considered to be "not particularly in character with their seaside setting." The area was in need of "tidying up" and piecemeal development "would prejudice. . .redevelopment of the locality."

Although there had been storms and/or floods in 1945, 1949, 1954 and 1962, natural hazards receive no mention at all throughout the nine-page document which focuses exclusively on the architectural and visual aspects of "development." That the utilitarian quality of much existing construction, considered to be so undesirable, may have resulted from an indigenous appreciation of sea hazards, altogether escaped the attention of the planning authority who seem to have considered Chiswell in the same "seaside" tradition as Edwardian Weymouth.

It is apparent that in the immediate post-war period of 1946 onwards, in which the 24-year planning boom had its genesis, all damaged buildings were considered to be a result of enemy action. That they included buildings damaged by the sea is certain, just as there are buildings in Chiswell now damaged by the sea in 1978 and 1979, and others derelict and said to have been damaged by earlier storms. Nevertheless, it is equally certain that even the great storm of 1824 was not

responsible for the complete destruction of many buildings no longer standing. Pictorial evidence shows most, if not all, of them standing and occupied some considerable time after 1824 (Bettey, 1970). It is, therefore, impossible now to isolate the effect of preceding storms on the "dereliction" and "blight" that the planners of the 1960's were so concerned about. That there would have remained storm damaged buildings at that time is certain, and storm therefore no doubt contributed to the planners' decisions, made during 1935 and 1961, to demolish or close a total of 36 dwellings considered to be sub-standard or unhealthy. Just as Chesil Beach, in the long term, is not being regenerated, neither, in the short term, was Chiswell. While geomorphic forces are partly responsible, some responsibility for Chesil's shrinkage was in the hands of social forces.

The "tidying-up" process and refusals for re-development had a totally negative result. Area designated as public open space still contains the foundation and some walls of dwellings demolished by man or sea, and no "development of the area as a whole" ever took place. A sea wall was completed in 1962 (with further work in 1965) and four new houses were built in 1970. In addition to the arrest (in ignorance of sea hazard) of spontaneous change that may otherwise have taken place, it has been suggested that removal of derelict buildings to seaward has increased the exposure to the sea of inner buildings (Chiswell Residents', 1979a). This may well be so. It is significant that the few remaining inhabited buildings of the rows that extended from the main street up the beach, are protected by the solidly built and long-standing Cove Inn which stands massive and erect on top of the sea wall and shingle ridge.

FLOOD AND STORM

Damage by sea-water is caused to Chiswell by seepage through the shingle bank as well as by overtopping. Arkell (1965) is at pains to distinguish between the two phenomena, there having been some confusion in written accounts since the sixteenth century with regard to the origin of flood waters. Nevertheless, evidence of both sources of flood water is given. In 1824, sea water rose to a depth of 22' 8" at the Swannery at Abbotsbury, which is virtually at normal sea level. On this occasion, a 100-ton sloop was carried over the shingle crest and was subsequently relaunched into Portland Harbour. The higher the sea rises up the shingle bank, the greater the pressure of water to cause seepage through the bank, the lesser the volume of shingle to obstruct seepage, and the larger the components of shingle--making seepage faster. Finally, there is overtopping by continued rising and by storm waves carried on top of a flood tide. When the sea is high, water seeps up out of the shingle bank on the landward side and runs between the buildings and dwellings of Chiswell to cause flooding, often exacerbated by heavy rain, which has itself occasionally caused some flooding.

Since 1824 there are references or accounts of 21 other storms and/or floods (see Appendix A). In the storm of 1942, seepage through the bank commenced an hour before waves began to sweep over the beach. Slight flooding that had by then occurred in Victoria Square, the lowest point, then began to become serious, and that area was eventually flooded to a depth of six feet. Waves were described as being 60 to 80 feet high. This height is probably exaggerated; and in any case, any such height would more likely have been achieved by waves of more normal

size on top of a high sea (Carr, 1979). Over 100 houses in Chiswell were flooded and the road and railway (now disused) on the causeway were breached. The Chairman of Portland Urban District Council compared the suffering of flood victims to those of enemy air attacks, being just as deserving of help, but not eligible for assistance from the Lord Mayor of London's Air Raid Distress Fund (Dorset Daily Echo, 1942). The storm occurred on December 13, the reports of damage being delayed for nine days due to war-time restrictions on news reporting.

On December 12, 1978, Victoria Square was flooded to a depth of four feet and high seas breached the causeway for five days. Winds were recorded as Gale Force 9 with gusts of up to 70 mph, and a section of the ridge of Chesil Beach was demolished. Police issued flood warnings in the early hours and residents adopted "a now familiar routine of taking emergency action to beat the floods." Nevertheless, as the full extent of the damage to houses and businesses became apparent, residents were reported to be expressing anger against the local Council of Weymouth and Portland (Dorset Evening Echo, 1978).

On February 13, 1979, before complete recovery from the December storms had been possible, the sea overtopped Chesil Beach "without warning" at 6:30 am. Whereas, in the December storm, there had been certain points along the ridge where overtopping occurred, on this occation there was a continuous sea which overtopped a very long area of the beach at a height of between 15 and 20 feet. Victoria Square was once again flooded to a depth of four feet, and parked cars were piled on top of each other, electricity and gas mains in the causeway were broken, masonry was swept through breaches in buildings, and 24 people were evacuated from their homes (Dorset Evening Echo, 1979).

Although the events of December, 1978 and February, 1979 caused similar results, they were caused by different phenomena and the experience of each was quite different. The storm which caused the December event was local and its results in Chiswell were direct, but the February sea surge was a result of a storm or storms in the Atlantic which, with coincident meteorological and hydrological conditions, sent the sea surge up the English Channel to be trapped by the promontory of Portland. There was no storm at Chiswell when the surge struck, hence the surprise and lack of natural warning when it occurred. The trap of the east coast of West Bay and Portland Bill was notorious for ships under sail and wrecks of ships that failed to round the Bill are countless. Storms such as that in December, 1978 are regular occurrences at Portland, with an estimated return period on Spring Tide of five years, with minor floods as frequent as twice yearly. However, the sea surge was not unique, the previous similar event having been in 1904, and the return period having been calculated as 50-70 years (Dobbie, 1979).

TECHNOLOGICAL CHANGE

In its approximate three-and-a-half square miles, the Isle of Portland contains, in addition to four principal communities (not including Chiswell), two ancient castles, quarries and stone works for Portland Stone, coastguard stations and Pulpit Rock Lighthouse, a prison and a Borstal (a reformative institution for juvenile offenders), hospital, a naval helicopter station, underwater weapons establishment, and dockyard installations and fuel depot for Portland Harbour. Most of these communities and establishments are elevated and, though exposed to

wind, are protected from the sea. Chiswell, almost at sea level, is a very small community incidental to the island's other activities and uses, but its main-street has become the main road off the island which passes through Victoria Square, and very near to the naval helicopter station.

The helicopter station was built by the Admiralty in 1962-63 over what had been Portland Mere, which, at the south-east end of the section of Chesil Beach which provides the causeway, had served the same drainage function as the Fleet still does to the larger section of the beach north-west of the causeway. Earlier maps marked The Mere as "Liable to Floods" which were caused, in part, by the drainage of sea water which had made its way through and over Chesil Beach adjacent to Chesil and had flowed naturally away into the Mere. The construction of the helicopter station on the site of the Mere has blocked the natural escape flow of excess water. Although there are two culverts, they do become easily blocked with rubbish and debris. There is a two-hour tide difference between high tides to the west and to the east of the causeway, that is between Lyme Bay and Portland Harbour/Weymouth Bay. The Mere formerly served as a collection or ponding area for excess water awaiting the ebb of the tide in Weymouth Bay. Even fully operative culverts require the low tide, and ponding now takes place in and adjacent to Victoria Square. Such was the volume of water trapped in this way in February, 1979 that the perimeter five-foot high stone wall of the station was demolished. Similarly, the conversion of Victoria Square into a roadway intersection roundabout has contributed to successive increases in the general road level as a result of roadworks and resurfacing. This may have had the effect of reducing the depth of

flooding in Victoria Square, but it further impeded the run-off of excess water from Chiswell. There are houses adjacent to Victoria Square which formerly had up to five steps from their elevated ground floor level to the Street, a sensible precaution unheeded by the highway engineers (Chiswell Residents', 1979a).

Chesil's primary vulnerability, which has increased for geomorphic reasons, is to the sea, the principal source of flood water. Secondary vulnerability to deeper and longer lying flood water has been brought about by technological changes over shorter time periods. In 1962 a sea wall and esplanade was constructed for a length of 1600 feet from the point where Chesil Beach runs into the north-east face of the island at Chesil Cove, to a point in line with a point half-way along Chesil. Construction was then considered possible only with foundations on clay. Construction on deep-shifting shingle was more difficult, which accounted for the apparently arbitrary end of sea-wall protection. Some time after its construction, an additional wall with piled foundations was constructed, since the foundations to the original wall were being undermined by the sea. Protection afforded Chiswell by the sea wall is evident and it is considered locally that the sea wall does offer protection, in so far as its limited height and extent. The construction of the sea wall also implies some acceptance of responsibility by the authorities concerned, for the safety of Chiswell. Nevertheless, the sea wall itself is overtopped from time to time (see Appendix A, Dec. 13, 1978), its design height being lower than the adjacent natural beach crest. Perhaps more significantly, it has been suggested that the

construction of the sea wall may partly explain the natural reductions in height of the adjacent beach crest (Carr and Gleason, 1972).

SOCIAL CHANGE

The authorities which have a direct responsibility for, or involvement in the storm and flood hazard, and conditions consequent to it, are the Wessex Water Authority, which has responsibility for coastal sea defences and the Weymouth and Portland Borough Council (amalgamated in 1974 from the two formerly separate councils) which has responsibility for most other factors affecting Chiswell such as evacuation, rehousing, relief and road maintenance. Both these authorities are able to apply to ministries within Central Government for financial grants, subject to the respective minister's approval within certain proportional maxima, in respect of work they undertake. Both authorities have a responsibility for the removal of excess surface water, shared according to its origin. Non-governmental organisations involved with raising and distributing relief funds at Chiswell have been the local Rotary and Lions Clubs, and the Round Table. Most recently, as a direct result of the December, 1978 and February, 1979 floods, there has been increased citizen and municipal concern. After the flooding of December, 1978, the Wessex Water Authority appointed a firm of consultant engineers to assess all available data relevant to flooding at Chiswell, to advise on probable return periods of the storms and floods, to advise on further studies necessary, and to suggest options, with budget costs, to "safeguard" Chiswell from flooding. The consultant engineers' report thoroughly investigates the meteorological and hydrological origins of

both the December, 1978 and February, 1979 events, and focuses on consideration of four principal options for coping with sea flooding. All the options considered are of constructed engineering measures to prevent flooding by seepage, overtopping, and to reduce the energy of sea waves. The important need for a warning system is emphasised, but in this respect "many problems remain to be solved." The report concludes with a recommendation for further studies and the preparation of a full report, estimated to cost £150,000 (US $335,000.00) (Dobbie, 1979).

The percentage of possible governmental-support for sea defence measures is higher in the case of submissions made by water authorities than those made by local authorities. For this reason the report of the consultant engineers was formally commissioned by the Wessex Water Authority and submitted to them, being sent at the same time to the Weymouth and Portland Borough Council. The council's activities in the meantime have focused on the drainage of flood waters, the operation of an emergency control centre, the use of earth-moving equipment to replace shingle from the rear of the beach to reform and maintain the ridge height, and on negotiations with owners where property has become unusable. A Special Sub-Committee of the Council's Policy and Resources Committee was appointed to consider the problems of flooding, necessary remedial action, and the future of the Chiswell area. In addition to the appointment of consultant engineers by the Wessex Water Authority, the Policy and Resources Committee commissioned an aerial and hydrographic survey.

It was not until a meeting on April 12, 1979 that formal consideration was given to letters from Chiswell residents regarding housing difficulties as a result of the floods (Weymouth and Portland, 1979a).

As a result, "It was felt by the Sub-Committee that the Council should take a positive move with regard to these properties as a first step towards regenerating the area, and to ensure that the community is revitalised." The Department of the Environment was to be approached by the council for possible financial assistance.

In fact, some Chiswell residents are unable to live in flood and storm-damaged properties upon which they are committed to mortgage repayments. Relief on these payments has in some instances been given, but for periods of three months, an insignificant period of time in relation to the scale of the damaging events experienced. While these conditions may not always be directly connected with Borough Council Administration, there is clearly no policy for their general consideration, nor their co-ordination. Neither is there, it would seem, any policy for engaging in the preparation of schemes for physical protection and prevention of flooding. Decisions for taking such measures are based on an acceptance of moral responsibility rather than as part of a specific policy declared as a result of comprehensive problem analysis.

Where there has been any consideration of social measures, in the preparation of flood and storm warnings, or in the consideration of means for property purchase and compensation, they have been secondary, and in the latter case, as a result of initiation from residents. The formation of the Chiswell Residents' Action Group (CRAG) itself is partly an expression of frustration and concern over the absence of stated policy on social measures. In fact, were a policy for property purchase and compensation to be introduced, a larger proportion of Chiswell residents would leave the area; local estimates are 20%-50% in addition to those who have left already. There are currently (May,

1979) 30 recently vacated domestic and commercial properties in Chiswell, and four are "for sale." Social measures cannot be left to the relief funds initiated and managed by voluntary organisations. The impressive £8,000 total of the fund for the two recent floods has made possible the allocation of only £140 each to 52 households, with £1,000 remaining in the fund, presumably to re-start the fund after the next flood.

CRAG has co-ordinated and mobilised local residents' opinion; has mobilised action for which individuals may have been, or felt themselves to have been, ineffective (1979c); has produced an "Analytical Report" concerning the flooding problems (1979a); has explored possible avenues for compensation or relief, such as discussing possibilities of reduction to property rates (1979c); has requested and achieved representative co-option as non-voting members of the meetings of Weymouth and Portland Borough Council; and has formally applied to the Disaster Fund of the European Economic Commission for financial aid for the alleviation of flooding at Chiswell (1979b). Although the authorities would claim that they would have similarly attended to the problems caused by flood at Chiswell whether or not there had been a residents' action group, it is apparent that the group's activities have been taken seriously. More emphatically, the authorities have acted in some respects only after approaches have been made to them by members of the group, but have not yet acted in all respects of the group's concerns.

The Wessex Water Authority considers itself to have a responsibility to protect communities from flooding, but point out that they are not obliged to do so. The Weymouth and Portland Borough Council state that they are "firmly of the view that Chiswell must be preserved, and indeed enhanced" (Portland Flooding Subcommittee, 1979). CRAG states

its objectives to include lobbying for "a scheme or schemes that will end for all time the danger of Chiswell from flooding" and "to ensure that the environment of Chiswell reflects the expectations of the people who reside there" (1979a). All these statements have been made before any full analysis of the flood problems that exist.

The Residents' Action Group balances, to some considerable extent, the absence of consideration of social measures to alleviate flooding from those measures taken by the authorities. However, as neither the authorities nor the action group have a policy formulated on logical analysis, but have discharged what they saw as their respective duties on the basis of moral concern, it is likely that discussion and negotiation between the two bodies may actually impede analytical processes and official policy formulation. The role of CRAG can only be that of a grass-roots "ginger group," whereas that of the authorities will continue officially in this and all other aspects. Had there been a logical policy formed by the authorities to include social measures at the outset, the formation of the action group may not have been necessary.

Furthermore, there is a conflict of roles between the individual and collective roles of the action group. Members are embarrassed by the activities of the group, for instance, in seeking compensation for reduced property values, when as individuals they may be trying to secure a temporary waiver of a local authority mortgage. There is also some concern on the part of individuals with regard to their own property value, and the efforts by the group to publicise the problems of the Chiswell community to a wider public who must possibly include prospective future purchasers. For these reasons alone, logical

formulation of policy and any concerted activity on it as a result cannot be a straightforward formula for success.

There are no available figures for the cost to the local authority of flood emergency services and repairs to its own roadways and property. The total cost of damage in the storm of 1942 was put at "several thousand pounds" (Dorset Daily Echo, 1942), and in 1972, after storms in February of that year, the total value of 45 damaged dwellings was put at £330,000 (Dorset Evening Echo, June 22, 1972). Total damage from the February, 1979 storm has been estimated at £250,000. These figures are estimates of total damage to property in local government ownership and that in private ownership. To these costs must be added the value of voluntary relief funds which have been established, either nationally, as in 1824, or locally, as more recently by the Rotary and Lions Clubs, and the Round Table. The joint fund raised by these three bodies in 1978 and 1979 totalled £8,228 (Dorset Evening Echo, 1979). The cost of the sea wall in 1962 was £180,000 and investment into the improvement of property since the Housing Improvement Act of 1962 could have been £1,000 per, say, half the dwellings in Chiswell since that time, and have totalled around, say, £35,000.

Should it be necessary for central government sources of grant-aid to apply rules of cost-effectiveness for proposals submitted to them for sea defences for Chiswell alone, it is difficult to see how they will be able to agree to fulfill their potential 65% proportion of the total cost. In such a case there could be no agreement for financial support and the project for sea defence would not go ahead; then it would be necessary for the inhabitants of Chiswell to reconsider their collective and individual alternatives. Clearly the only alternatives remaining

would be either to accept continued, and increased, risk or to move away, in the hope of compensation for loss of property or property value. It is that option which should have been safeguarded in the first instance as a matter of policy. Only when the size of the remaining community is known can any cost effectiveness for civil engineering preventive measures be known.

In the 1960's, the fishermen who formerly lived in Chiswell were offered alternative accommodation in recently completed housing rentable from the local authority. All of them accepted. Had an opportunity been provided at that time for all house owners to have the option of vacating their properties, and had all vacated properties not been re-occupied by newcomers, recent problems would not have occurred to such an extent. Particularly since the Housing Improvement Act of 1962, local governments with financial backing from central government have assisted owner-occupiers to improve their properties with a system of grants. Where central and local authorities are prepared to be involved at a domestic level for the purpose of improving the nation's housing stock, they must surely be prepared to be involved, also at a domestic level, where financial inducement may have promoted occupation of property in a hazardous location.

In any case, involvement of the authorities on the one hand may encourage a reliance upon the authorities on the other. The authorities must, therefore, through planning processes, be as aware of natural hazard situations as private individuals and property purchasers might be expected to be. Where there is a potential partnership in one case between the state and the individual, a partnership cannot be avoided on the other; both are equally in the interest of the state.

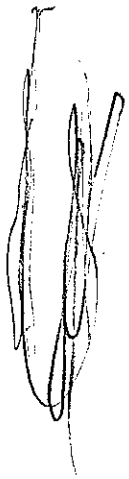
There appears to be every reason for developing a scheme to be operated by local authorities, with financial support from central government funds, to secure the same option of domestic mobility, in a situation of hazard, as is enjoyed by members of communities subject only to normal market forces of supply and demand of dwellings. The formulation of this kind of policy for social measures should have priority over the application of physical constructed preventive measures. Legislation for government support should be initiated to counterbalance the comparatively long history of legislation that exists for financial support of sea defences and flood prevention (e.g., Coastal Protection Act 1949; Land Drainage Act 1976).

The blinkered approach of the planners in the 1960's demonstrated the power and significance of social measures, which would have more positive results where integrated into a comprehensive policy. Not only was Chiswell diminished by the activities of the planners, but vulnerability of the community that remained was increased by removal of some buildings and by emphasis of the fatuous concept of Chiswell as a seaside resort, rather than as a practical working community.

In a time of energetic concern for environmental conservation, it could be proposed that Chiswell be protected as a designated Conservation Area, in view of its long history. Such proposals would go beyond any quantifiable application of cost-effectiveness, but do fit with conservation policy. As is the case for many working communities, Chiswell was apparently a visually attractive place at the turn of the century and after, but has since suffered from enemy action, post-war planners, and storms. However, preservation will not serve to hold back the encroaching shingle, as has been suggested. The shingle has been

shown to be inexorably advancing landwards, and the vulnerability of Chiswell has increased. People and community are a part of environment, not separate from it. The sea and shingle, which once created opportunity, taken by people, for advantageous proximity to the sea, now choose in time to take that opportunity away. Practical advantages, once predominant, are being slowly supplanted by the disadvantages of hazard.

Preventive measures for hazard must be formulated to take comprehensive account of the relationship of man and his environment, and must be considered as ecological adjustments of vulnerable people and their elected administrations to counter the effects of disaster, rather than only as technological resistance to the forces of hazard (Lewis, 1979). Ecology here must be understood in its widest sense to include the relationship of man with his social and political environment, as his means of effective relationship with his physical environment. That some of man's options with regard to physical environment will be controlled by his administrators means that this must also be understood by those administrators if all options are to remain open and operable. The important significance of the social component of vulnerability, in community grouping and administrative functioning, has to be balanced by social measures for prevention.



Just as vulnerability is compounded of physical and social conditions, so also must preventive measures be compounded of physical and social measures. Preventive measures seek to mitigate disaster by reducing impact or by reducing numbers of people to suffer impact. Although many of these measures will be taken individually, they may be advised and encouraged by local authorities in hazardous areas both as a

matter of course and when extreme events are about to occur. The preparation of warnings and the dissemination of warnings is of prime importance in preparedness measures. Advice on hazards to be expected, on what to do, on how to secure property against flood, on what evacuation procedures will be available, on how and where to make contact with the authorities, and on what measures various authorities will be undertaking in the event, are all examples of preparedness planning (Lewis, 1977). It is obvious that preparedness planning is multi-disciplinary and multi-sectoral and calls for the closest integration of measures to be taken by authorities and the public at domestic level.

There is, however, an additional factor, which has overbearing implications for policy formulation in respect of natural hazard at Chiswell. Twelve-and-a-half thousand people live on Portland; some commute to the mainland and probably several thousand more commute from the mainland to the institutional, scientific, military and commercial establishments on the island. The exacerbating effect on secondary hazard at Chiswell due to the activities of, and on behalf of, some of these establishments has been described. More significantly, they are all served by the causeway road and by the one-way road approach and exit system to the island which includes the main street of Chiswell. The causeway road and the electricity, gas, water and telephone utilities are all afforded protection from the sea by Chiswell Beach, as are the naval fuel tanks, the naval helicopter station and the western side of Portland Harbour itself. If vulnerability to the sea is increasing for Chiswell, it is increasing for these institutions and their communications and utilities similarly. This may make all the difference to considerations of cost-effectiveness for sea defences, or to the

possibility of obtaining financial support for them, either from the normal source in the Ministry of Agriculture, Fisheries and Food, or from within the Ministry of Defence, or the Home Office (although there appears to be no precedent for such multi-sectoral finance). In this case, however, the danger to Chiswell may be from increased secondary hazard. There is also the added danger of preventive measures designed for longer return periods permitting and encouraging development of Chiswell, which may bring about larger disaster on the rarer occasion of eventual overtopping (White, 1974).

CONCLUSION

In 1972 permission was finally refused to allow the removal of pebbles from Chesil Beach for commercial purposes, but this only after a planning decision had been made by the Planning Committee of the Portland Council to allow removal of pebbles. Objections had been mobilised by local action, planning permission refused, an appeal submitted by the applicant, and a public inquiry held in which the appeal was disallowed. There had been a previous public inquiry into a similar situation in 1968, when permission had been granted. In 1906, shingle was removed from the beach for infilling purposes in the construction of the naval dockyard fuel tanks directly adjacent (Morris, n.d.); in 1968, the rate of "pebble picking" at the eastern end of the beach was said to be 100 tons a year and not very significant (Carr, 1969). However, the history of the removal of pebbles at Chiswell reflects a history of public ecological concern, and such concern probably reflects the history of public participation in local government affairs. The mobilisation of

public concern, by its nature, is multi-disciplinary, whereas administrative decision-making is often political, usually sectoral, and constituted on advice prepared by mono-disciplinary staff and/or consultants for sectoral clients. Extraction of pebbles, in larger quantities than at Chiswell, is continuing some 25 miles along the Dorset coast at West Bay. Removal of aggregate is licensed by the West Dorset District Council who receive a royalty per ton; meanwhile, expenditure is being incurred by nearby authorities to combat coastal erosion and flooding (Carr, 1979).

The incompatability of administrative activities in a common ecological context calls for a more comprehensive formulation of policy, and for its implementation at national and local levels. What are the implications from this study of conditions at Chiswell for such a policy?

First, policy formulation must be undertaken in a pre-disaster condition of hazard, and not as a result of pressure in a post-disaster emergency.

Next, policy formulation cannot be the prerogative of either national, or local, authorities. It must be the result of the integration of all levels of concern and responsibility. At no administrative level can effective policy formulation proceed as a mono-sectoral or mono-disciplinary pursuit; all interests must be represented, understood and integrated.

At local levels, public understanding must be promoted, and public participation invited. "Ginger group" pressure, which may result as an alternative, may be an impediment to ordered analytical processes. The results of policy formulation may <u>not</u> be to maintain a status quo.

The cost-effectiveness of physical measures can only be assessed after social measures have been considered. That is, measures for civil engineering cannot be realistically assessed for effectiveness until the nature and size of the community they are designed to protect has been determined.

Legislation is required to permit compensation for owners who vacate property due to hazard; they ought to have that option available to them without restrictive financial loss.

All measures, initiated or advised by authorities, must take into account the involvement of people for whom they are intended, and people must, conversely, know the full range of options open to them, and which authority is responsible for each.

Historical context assists the understanding of future change. Future time scales of specific hazards must be considered for preventive measures and preparedness measures. Preventive measures must be considered as adjustments in the activities of vulnerable people, and their elected administrators, to counter the social effects of hazard events, not only as technological resistance to environmental forces.

Where central and local governments have been involved in programmes of improvement to housing stock, with assistance for its purchase, they must be prepared to be involved where compensation due to environmental hazard is concerned. Involvement by authorities, on the one hand, may have encouraged reliance on authorities on the other; authorities must, therefore, be as fully aware of natural hazard as potential property owners are expected to be.

Knowledge in the physical and social sciences must be made useful to the public. Scientists and academics must adopt a responsibility for this, beyond the requirements of their own disciplines and sectors.

Authorities and organisations already established with a concern for protection of environment from man, must embrace the concept of man as a component of natural environment. By so doing, man's protection from environmental hazard may be more assured.

BIBLIOGRAPHY

Arkell, W.J.
1965 "The Effects of Storms on Chesil Beach in November 1954." Proceedings, Dorset Natural History and Archeological Society 76: 141-145.

Bettey, J.H.
1970 The Island and Royal Manor of Portland: Some Aspects of its History. Prepared for the Court Leet and Royal Manor of Portland. Bristol: University of Bristol Dept. of Extra-Mural Studies.

Carr, A.P.
1969 "Size Grading Along a Pebble Beach." Journal of Sedimentary Petrology 39 (March): 297-311.

1978 "The Long Chesil Shingle." Geographical Magazine 50: 677-680.

1979 Personal Communication, September 10. Taunton, Somerset: Institute of Oceanographic Sciences.

Carr, A.P. and M.W.L. Blackley
1974 "Ideas on the Origin and Development of Chesil Beach, Dorset." Proceedings, Dorset Natural History and Archeological Society 95: 9-17.

Carr, A.P. and R. Gleason
1972 "Chesil Beach, Dorset and the Cartographic Evidence of Sir John Coode." Proceedings, Dorset Natural History and Archeological Society 93: 125-131.

Chiswell Residents' Action Group
1979a "An Analytical Report Concerning the Flooding Problems in Chiswell, Portland." March.

1979b Letter to the President of the European Commission. April 11.

1979c "Statement Concerning the Proposals put forward by the Policy and Resources Committee on the Alleviation of Flooding in Chiswell, Portland." April 22.

1979d CRAG Bulletin #1(March)and #2(April).

Davey, R.F.
1979 "The Giant is Dead: The Magnificent Chesil Beach is not Being Renewed by the Sea." Dorset Evening Echo Weekly Review (January 24). Weymouth.

Dobbie, C.H. and partners
1979 Preliminary Report on Flooding at Portland. Report to the Wessex Water Authority. Southampton.

Dorset County Council
1964 Report on Chiswell Area, Portland. South Area Planning Office.

Dorset Daily Echo
1942 Weymouth, Dorset, December 22.

Dorset Evening Echo
1978 Weymouth, Dorset, December 12-16.

1979 Weymouth, Dorset, February 13-15.

HMSO
1933 Census of England and Wales, 1931. Part 1, County of Dorset. London.

Kelly's Directories Ltd.
1939 Kelly's Directory of Dorsetshire, 1939. London.

Lewis, J.
1977 A Primer of Precautionary Planning for Natural Disaster. Bradford: University of Bradford Disaster Research Unit.

1979 "The Vulnerable State: An Alternative View." Chapter 5 in Stephens and Green (eds.) Disaster Assistance: Appraisal, Reform and New Approaches. New York: New York University Press.

Morris, S.
n.d. Files on the History of Chiswell. Chiswell, Dorset.

1979 Resumé of the History of Flooding at Chiswell since 1824. Chiswell, Dorset.

Portland Flooding Sub-Committee
1979 Minutes of Meeting, April 6. Weymouth: Weymouth and Portland Borough Council.

Western Gazette
1942 Undated article. Weymouth, Dorset.

Weymouth and Portland Borough Council
1979a Official Notice and Reports: Minutes of Meeting, 15 March. Weymouth, Dorset.

1979b Official Notice and Reports: Policy and Resources Committee, 15 March. Weymouth, Dorset.

White, G.F.
1974 "Natural Hazards Research: Concepts, Methods and Policy Implications." In White (ed.) Natural Hazards: Local, National and Global. New York: Oxford.

Williams, W.W.
1960 Coastal Changes. London: Routledge and Kegan Paul.

Wolman, M.G. and J.P. Miller
1960 "Magnitude and Frequency of Forces in Geomorphic Processes." Journal of Geology 68: 54-74.

APPENDICES

APPENDIX A

The following is a chronology of storm and flood at Chiswell, Dorset, with descriptive notes (Morris, 1979).

Years in which storms and/or floods have occurred at Chiswell since 1824:

1824, 1853, 1865, 1883, 1899, 1903, 1904, 1924, 1936, 1942, 1945, 1949, 1954, 1962, 1971, 1972, 1974(2), 1976, 1977, 1978, 1979.

The longer intervals between storms in the earlier years must be taken to reflect a scarcity of record of an accepted hazard, not necessarily a lesser frequency of occurrence.

November 22nd, 1824

> In the Evening of this day, which will ever be memorable for the dreadful Catastrophe which caused such destruction along the whole Western Coast of the Kingdom, the village of Chisel was nearly destroyed, twenty-six of the Inhabitants drowned, and upwards of eighty Houses damaged or washed down by a tremendous Surf which broke over the Chisel Bank, and bore everything away with irresistible violence before it. This awful Visitation was occasioned by a heavy Gale, which, happening at a Spring Tide, and commencing from the South South East, increased till eight o'clock, when it blew a most dreadful Hurricane, such as never had been known before in the memory of Man. At nine o'clock a most horrid scene presented itself. The Sea ran down the Streets of Chisel with a sufficient depth of water to float a vessel of a hundred tons burden: and the Wrecks of the Houses, with the furniture of the poor Inhabitants, were every where strawed on the Shore. The Ferry House leading to Portland was washed away, and the Ferry Man drowned. The Communication between the Island and the Mainland was nearly destroyed by the ravages of the Sea, which carried away the Sand Bank on the Eastern Side, and rendered the passage four times wider than it was before. The Chisel Bank throughout its whole extent was lowered from twenty to thirty feet; and the Saines and Boats of the poor Fishermen of Wyke, as well as those of Portland, almost totally destroyed. The Pier of Weymouth Harbour was materially damaged, and three fourths of the Esplanade at Melcombe Regis entirely thrown down and demolished. The Waves of the Sea washed over the high Road

at Melcombe Regis, and filled all the lower parts of the Houses in Gloucester Row, and the Crescent with gravel and water. In short, a Scene of greater distress and misery can hardly be conceived, than was occasioned by this Storm. And its dreadful Effects will never be effaced from the minds of those who witnessed it. The same Storm destroyed the Church at Fleet, and threw down several Houses, but fortunately no lives were lost. The Colville West India Man of four hundred tons burden was totally wrecked in the West Bay, and every Soul on board perished, besides several minor wrecks too numerous to mention.

George Chamberlaine, Rector of Wyke
16th December, 1824
(Bettey, 1970:2)

December 2nd, 1865

Dense volumes of water were poured upon the ridge of the Chesil Beach and, percolating through, flooded the houses in the village of Chesil, and in some places deluged the turnpike road, rendering it impassable in certain points.

The sea also undermined a portion of the new Weymouth-Portland Railway (opened only that year). The rails had to be relaid.

February 13th, 1899

A "furious storm" of thunder and hail between 8.30 and 9.00 a.m. on the 12th. This persisted into the 13th when the gale was "very severe." At Chiswell the "sea was so high as to filter through the pebbles and run into the streets." However, "little damage was done." The older cottages had stone or well-seasoned timber floors with flood ducts beneath. Occasional sea flooding was an accepted fact of life.

February, 1904

Chiswell was flooded by a "tidal wave," the houses on the beach subjected to a deluge of sea water and mud "which has caused almost irreparable damage to the property in the village."

This was preceded by a heavy ground swell causing waves of considerable length to rush up the beach, and "to drag away the pebbles until the usually three-banked tier was transformed into one long slope from the 'dirt' down to the water." As with the February, 1979 flood, the wind was from the south-east, so "little damage was expected."

At 6.30 a.m. a "gigantic tidal wave," which had caused so much destruction two hours before in the Scilly Islands, swept up the Channel to hurl itself on the already weakened beach. Workers in Barnes Stone Yard (by the station) managed to escape while the water in the Square was still only knee deep, but this was soon "impassable," "White-crested breakers came over the top." Houses in Brandy Row, Big Ope etc. were inundated with water, carrying "stones, baulks of timber and mud by the ton." Pebbles were hurled against doors.

At 8.00 a.m. the inroad ceased, but "Chiswell was three feet deep. Victoria Square was quite full, and all along the Weymouth Road there seemed a long river." There was little or no wind at the time. The depth of water on this line prevented trains running from 7.00 to 9.00 a.m.

The rush of water put out all the fires in the Gas Works. Depth in the centre of the Square reached 3 ft. Flood subsided late morning, leaving mud. "Every house at low level had its floor covered." The mud took two days to clear from the streets. The gas supply was cut for a day.

January, 1924

"Chesil has been very badly flooded. This is not an uncommon experience. The householders are sometimes driven out of homes by the invasion of the sea." "Degree of calamity has surpassed previous levels."

November 11th, 1936

"A huge wave broke over Chesil Beach and the sea rushed through the pebbles." King Edward VIII was in the station with 2'0" of water under his train at 5.30 a.m. By 8.00 the wind had lessened, but communications with Weymouth were still cut off.

"More than half of the Weymouth-Portland Road was under five feet of flood-water." Large numbers of cars held up at Wyke, including two coach loads of police who were attending the Royal visit. They eventually reached Portland by walking the railway line. Train service was resumed by 9.00 a.m., bus services by noon. By midday the floods had subsided a great deal, most cars could then get through despite a depth of 16" in places.

Boats on Chesil Beach were badly smashed. Two residents had narrow escapes when one wave broke over. At no. 131a Chiswell, for example, a wave "dashed against the rear of

the house, smashing the scullery roof and windows and flooding each of the downstairs rooms."

A dozen or so cars and motorcoaches were marooned on the beach road.

"Several parts of the bank at the top of the Chesil Bank were swept away during the storm." Warnings were given about gas supplies being shut-off.

December 13th, 1942

At 11.00 a.m. there was severe flooding. "The sea came over and through Chesil Beach, flooding Victoria Square, Chiswell and a long stretch of Weymouth Road and did considerable damage to private property, the Council's gas works, the railway and Weymouth Road."

This seems to be the first flooding to be the subject of a full engineering report.

A relief fund was opened.

The sea poured over for about three hours, and the water started to subside at about 2 p.m. The road was cleared for traffic the same night. The railway was damaged and this was not opened for three days. Repairs to the railway cost £1,000. Assistance was given by the Army, Navy, Borstal and Civil Defence.

Waves "as high as 60 ft." were whipped up by winds of 80 mph. "Up to 6 ft. of water in Victoria Square, and when this subsided there was 6" of mud."

"For 10 hours the road was 4 ft. deep in sea water and houses in Chiswell and in Victoria Square, residents being marooned in their bedrooms."

"When the water had subsided pebbles and mud was everywhere. The Council employees and others eventually cleared the roads."

This was generally agreed to be the worst storm since 1824. Many houses built with backs to the beach lost their protecting walls.

Water was four feet deep in the railway goods yard. The Council Clerk reported that 150 houses were damaged, and there was no compensation payable. The stone wall along the beach road was reduced to rubble at many points. "Silt and yellow clay covered some floors to a depth of a foot."

This storm received national press coverage.

The PUDC Engineer later reported that there was flooding on three successive tides, the road being closed for much longer than usual. "The average number of flooding occasions is about two per annum."

October 26th, 1949

"Mountainous seas swept over Chesil Beach" in the night. Portland was cut off. The road was flooded and the railway line cut when the embankment subsided. An engine was derailed and dragged 6 feet. Wind reached 64 mph. Victoria Square was flooded to a depth of two feet. In five places the stone wall between the road and railway was washed away.

Water still covered the road in afternoon, but by then it was passable. No "medium or light" traffic could get through between 11.00 p.m. and 8.00 a.m. The wind changed from S.W. to N.W. during the night, speed 48 to 64 mph (coastguards).

November 27th, 1954

Sea flooding.

January 18th, 1962

There was severe flooding, described (probably incorrectly) as the worst in living memory. "High tides and gale force winds whipped sea over Chesil Beach and within 30 minutes the area was under up to 4 ft. of water." There was extensive damage to carpets and furnishings. The new sea wall was undermined where no sheet piles existed; some loose fill washed out, but there was no serious damage.

Residents had little warning; at 8.00 a.m. all was well, by 8.30 whole area was flooded and water was rising. The Kitchen of Victoria Cafe was flooded, Aitchesons Garage (east side of Square) was under four feet of water. Dozens of cars were marooned. The Mere emergency route was opened, but this too became flooded. Clements Lane was seriously hit.

December 13th, 1978

An Atlantic depression and high prolonged winds led to surge conditions such that the predicted tide level at Portland was exceeded by about 0.5 m. The waves generated were not recorded and have been estimated at four to five metre wave height. As the waves built up, the storm beach was removed, the main bank was severely denuded and steepened, and a huge volume of beach material was carried to

sea. A substantial lowering of the crest level occurred for some 40 metres, the back slope becoming seriously eroded due to the flow of water through the bank and overtopping, but the beach itself was not breached. The stability of the front slope was suspect and there could have been a serious breach. Fortunately, within a week there was a build-up of beach material and a reappearance of the stepped storm beach.

At the junction of the beach and sea wall, a serious recession of the beach developed into which large stone blocks were tipped, thereby avoiding outflanking of the wall. The wall was continually overtopped during the storm, when large quantities of shingle were carried over into Chiswell (Dobbie, 1979).

February 13th, 1979

In the morning Chesil Beach was, without warning, suddenly overwhelmed by long swell waves of 18 seconds period. It is recorded that from the 11th to the 13th a meteorological depression travelled towards the English Channel at the same speed, on the same course and on top of a long-period ocean swell. The beach flattened under such wave action and the easy run-up so produced resulted in severe overtopping and the transport of large quantities of beach material onto the back face of the bank in a "rolling back" operation. Extensive damage and flooding resulted from the overtopping and percolation which occurred (Dobbie, 1979).

NATURAL HAZARD RESEARCH WORKING PAPER SERIES
Institute of Behavioral Science #6, Mail Code 482
University of Colorado, Boulder, Colorado 80309

The Natural Hazard Research Working Papers series is a timely method to present research in progress in the field of human adjustments to natural hazards. It is intended that these papers will be used as working documents by the group of scholars directly involved in hazard research as well as inform a larger circle of interested persons.

Single copies of working papers cost $3.50 per copy. It is also possible to subscribe to the working paper series. A subscription entitles the subscriber to receive each new working paper as it comes off the press at the special discount rate of $2.00 per copy. The subscription itself costs nothing; when a new working paper is sent to a subscriber it is accompanied by a bill for that volume.

1 The Human Ecology of Extreme Geophysical Events, Ian Burton, Robert W. Kates, and Gilbert F. White, 1968, 37 pp.

2 Annotated Bibliography on Snow and Ice Problems, E. C. Relph and S. B. Goodwillie, 1968, 16 pp.

3 Water Quality and the Hazard to Health: Placarding Public Beaches, J. M. Hewings, 1968, 74 pp.

4 A Selected Bibliography of Coastal Erosion, Protection and Related Human Activity in North America and the British Isles, J. K. Mitchell, 1968, 70 pp.

5 Differential Response to Stress in Natural and Social Environments: An Application of a Modified Rosenzweig Picture-Frustration Test, Mary Barker and Ian Burton, 1969, 22 pp.

6 Avoidance-Response to the Risk Environment, Stephen Golant and Ian Burton, 1969, 33 pp.

7 The Meaning of a Hazard--Application of the Semantic Differential, Stephen Golant and Ian Burton, 1969, 40 pp.

8 Probabilistic Approaches to Discrete Natural Events: A Review and Theoretical Discussion, Kenneth Hewitt, 1969, 40 pp.

9 Human Behavior Before the Disaster: A Selected Annotated Bibliography, Stephen Golant, 1969, 16 pp.

10 Losses from Natural Hazards, Clifford S. Russell, (reprinted in Land Economics), 1969, 27 pp.

11 A Pilot Survey of Global Natural Disasters of the Past Twenty Years, Research carried out and maps compiled by Lesley Sheehan, Paper prepared by Kenneth Hewitt, 1969, 18 pp.

12 Technical Services for the Urban Floodplain Property Manager: Organization of the Design Problem, Kenneth Cypra and George Peterson, 1969, 25 pp.

13 Perception and Awareness of Air Pollution in Toronto, Andris Auliciems and Ian Burton, 1970, 33 pp.

14 Natural Hazard in Human Ecological Perspective: Hypotheses and Models, Robert W. Kates (reprinted in Economic Geography, July 1971), 1970, 33 pp.

15 Some Theoretical Aspects of Attitudes and Perception, Myra Schiff (reprinted in Perceptions and Attitudes in Resources Management, W. R. D. Sewell and Ian Burton, eds.), 1970, 22 pp.

16 Suggestions for Comparative Field Observations on Natural Hazards, Revised Edition, October 20, 1970, 31 pp.

17 Economic Analysis of Natural Hazards: A Preliminary Study of Adjustment to Earthquakes and Their Costs, Tapan Mukerjee, 1971, 37 pp.

18 Human Adjustment to Cyclone Hazards: A Case Study of Char Jabbar, M. Aminul Islam, 1971, 60 pp.

19 Human Adjustment to Agricultural Drought in Tanzania: Pilot Investigations, L. Berry, T. Hankins, R. W. Kates, L. Maki, and P. Porter, 1971, 69 pp.

20 The New Zealand Earthquake and War Damage Commission--A Study of a National Natural Hazard Insurance Scheme, Timothy O'Riordan, 1971, 44 pp.

21 Notes on Insurance Against Loss from Natural Hazards, Christopher K. Vaughan, 1971, 51 pp.

22 Annotated Bibliography on Natural Hazards, Anita Cochran, 1972, 90 pp.

23 Human Impact of the Managua Earthquake Disaster, R. W. Kates, J. E. Haas, D. J. Amaral, R. A. Olson, R. Ramos, and R. Olson, 1973, 51 pp.

24 Drought Compensation Payments in Israel, Dan Yarden, 1973, 25 pp.

25 Social Science Perspectives on the Coming San Francisco Earthquake--Economic Impact, Prediction, and Construction, Cochrane, Haas, Bowden and Kates, 1974, 81 pp.

26 Global Trends in Natural Disasters, 1947-1973, Dworkin, 1974, 16 pp.

27 The Consequences of Large-Scale Evacuation Following Disaster: The Darwin, Australia Cyclone Disaster of December 25, 1974, J. E. Haas, H. C. Cochrane, D. G. Eddy, 1976, 67 pp.

28 Toward an Evaluation of Policy Alternatives Governing Hazard-Zone Land Uses, E. J. Baker, 1976, 73 pp.

29 Flood Insurance and Community Planning, N. Baumann, R. Emmer, 1976, 83 pp.

30 An Overview of Drought in Kenya: (Natural Hazards Research Paradigm), B. Wisner, 1976, 74 pp.

31 Warning for Flash Floods in Boulder, Colorado, Thomas E. Downing, 1977, 80 pp.

32 What PeoOle Did During the Big Thompson Flood, Eve C. Gruntfest, 1977, 62 pp.

33 Natural Hazard Response and Planning in Tropical Queensland, John Oliver, 1978, 63 pp.

34 Human Response to Hurricanes in Texas--Two Studies, Sally Davenport, 1978, 55 pp.

35 Hazard Mitigation Behavior of Urban Flood Plain Residents, Marvin Waterstone, 1978, 60 pp.

36 Locus of Control, Repression-Sensitization and Perception of Earthquake Hazard, Paul Simpson-Housley, 1978, 45 pp.