Environmental Protection Report

LAND USE PRACTICES AND PATHWAYS OF PESTICIDE RESIDUES IN THE MOUNT'S BAY CATCHMENT, CORNWALL

April 1992
FWP/92/003
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NRA
National Rivers Authority
South West Region

LAND USE PRACTICES AND PATHWAYS OF PESTICIDE RESIDUES IN THE MOUNT'S BAY CATCHMENT, CORNWALL.
Technical Report No. FWP/92/003

SUMMARY.

Investigations in the Newlyn Catchment in Cornwall have demonstrated that runoff from aldrin-treated bulb fields lead to pesticide contamination of river water, sediments and fish. Following this, work has been commissioned to document the historic use of aldrin in other catchments renowned for bulb growing and to examine pesticide pathways to watercourses.

A study was commissioned by NRA South West to investigate pesticide usage in the Mount's Bay Catchment with particular attention being paid to the historic use of aldrin and was awarded to Soil Survey and Land Research Centre, Starcross, Exeter. Simazine and carbendazim were also identified as other likely pesticide contaminants in common use in the Mount's Bay Catchment. The use and pathways of these pesticides were also examined to indicate the wider movement of pesticides in catchments.

Over 180 fields were found to have been treated with aldrin in the Mount's Bay area. Increases of aldrin and dieldrin concentrations were demonstrated both in colluvium and turbid runoff. Pesticide residues were shown to access the watercourse via turbid runoff even during low intensity rainfall with an estimated return period of 2 weeks.

Pollution by dieldrin, carbendazim and simazine was demonstrated (up to 2320 ng/l dieldrin) in river water (Environmental Quality Standard for combined aldrin and dieldrin= 30 ng/l until January 1994). Future control methods, involving appropriate land use practices, were recommended to be included into the Code of Good Agricultural Practice.

It is recommended that the contents of this report together with the previous reports on the Hayle and Newlyn catchments should be discussed with MAFF in order to secure suitable land use and management codes of practice to ensure effective control of polluting substances entering watercourses. Furthermore, the routine river monitoring of the Mount's Bay Catchment should be reviewed to ensure that appropriate monitoring of pesticide concentrations in river water is undertaken.

FWP/92/003

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LAND USE PRACTICES AND PATHWAYS OF PESTICIDE RESIDUES IN THE MOUNT'S BAY CATCHMENT, CORNWALL.

1. INTRODUCTION.

Following the identification of high pesticide residues in eels and trout in the Newlyn Catchment in 1988, enhanced routine monitoring of river water quality, sediments and biota was instigated in the Newlyn Catchment. Further work showed that aldrin entered the river in turbid runoff from aldrin-treated daffodil bulb fields. As a result in May 1989 MAFF imposed a ban on the use of aldrin for bulb growing activities.

Since these investigations, work has been commissioned to document the use of aldrin historically in catchments renowned for bulb growing and to define the pathways of aldrin to watercourses. At the same time it was important to identify other pesticides in common use in the catchments and assess possible pathways for these pesticides into watercourses. Information on the concentrations of these pesticides accessing watercourses was then required.

2. METHOD.

A study was commissioned by NRA South West to investigate pesticide usage in the Mount's Bay Catchment with particular attention being paid to the historic use of aldrin. Assessment was then made of those pesticides commonly used for agricultural purposes in the catchment. Assessment was made of those pesticides likely to enter watercourses and for which analytical methods were available for detection in water. For those pesticides which fulfilled the criteria (simazine and carbendazim) pathways to watercourses were examined and concentrations in watercourses assessed to indicate the wider movement of pesticides. Recommendations for future control of these pesticides in watercourses were required.

A contract was awarded to Soil Survey and Land Research Centre, Starcross, Exeter. This study involved measurements of pesticide residues in soil, colluvium, runoff and in river water.

3. RESULTS.

A report has been produced titled " Land Use Practices and Pathways of Pesticide Residues in the Mount's Bay Catchment, Cornwall" with a supplementary report containing the "Analyses undertaken in support of the study of land use practices and pathways of pesticide residues in the Mount's Bay Catchment, Cornwall 1991". Both of these reports have been appended to this summary report.

In excess of 180 fields within an area indicated on Figure 2 were shown to have been treated with aldrin at least once in the Mount's Bay area. Dieldrin concentrations up to 1049 ug/kg were recorded in the soil. Where the use of aldrin was restricted to the dipping of broccoli roots aldrin concentrations in soil were found to be at or near the analytical detection limits.

Enhancement of soil pesticide concentrations was shown to be in the order of 1.3X in colluvium and 7.6X in turbid runoff. Similar measurements with simazine and carbendazim were inconclusive due to variability in the data.

Runoff was demonstrated to occur from a range of crops under rainfall intensities calculated to have return periods of only 2 weeks. The fate of runoff was traced to watercourses or road drains at 8 of the 16 sites. Furthermore, pesticide concentrations were shown to increase as the suspended solid concentrations rose.

4. DISCUSSION.

Even with only modest rainfall when the soil is saturated (field capacity) pollution by dieldrin, carbendazim and simazine was demonstrated (up to 2320 ng/l dieldrin) in river water. Pesticide enhancement in colluvium and turbid runoff suggested that the soil material retained in suspension or colloidal form (organic matter and clay-size particles) are particularly important as sites of pesticide residues.

The findings of this work support and complement the investigations already undertaken in the Hayle and Newlyn Catchments.

The recommendations include appropriate cropping, soil management and land use strategies that should be implemented in this area to mitigate pollution of the watercourses by these persistent pesticides. Enhanced monitoring of river water quality, especially storm-event related, has also been recommended.

5. CONCLUSIONS.

1. Over 180 fields were found to have been treated with aldrin in the Mount's Bay area.

2. Enhancement of aldrin and dieldrin concentrations was demonstrated both in colluvium and turbid runoff.

3. Pesticide residues were shown to access the watercourse via turbid runoff during low intensity rainfall (with a return period of approximately 2 weeks).

4. Future control methods, involving appropriate land use practices, were recommended to be included into the code of good agricultural practice.

6. RECOMMENDATIONS.

1. The contents of this report together with the previous report on the Hayle and Newlyn catchments should be discussed with MAFF in order to secure suitable land use and management codes of practice to ensure effective control of polluting substances entering watercourses.

- Action by Freshwater Officer.

2. The routine river monitoring of the Mount's Bay Catchment should be reviewed to ensure appropriate monitoring of pesticide concentrations in river water is undertaken.

- Action by Freshwater Officer and Freshwater Scientist.

LAND USE PRACTICES AND PATHWAYS OF PESTICIDE RESIDUES IN THE MOUNT'S BAY CATCHMENT, CORNWALL

by T R Harrod, BA, PhD

An investigation commissioned by the
National Rivers Authority,
South West Region

Contract No. 82/3982

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March 1992

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Summary

INTRODUCTION The work surveys land use practices in catchments entering Mount's Bay, with regard in particular to movement from the land to water of pesticide residues. The conclusions are very similar to those made in the Newlyn and Hayle catchments.

THE LAND Grassland dominates the catchment's land cover. However, near to the English Channel, particularly around the "Golden Mile", field vegetables and horticultural crops are grown to exploit the exceptionally mild climate and generally free draining soils. Potatoes, broccoli, cabbage and cereals are grown in rotation, with some double cropping. Daffodils are and have been grown on many holdings.

PESTICIDE USE For the crops grown, this is unexceptional. In the past, control of bulb-fly has been through soil-applied aldrin. In excess of 180 fields are known to have received the pesticide at least once between the early 1960s and 1989.

PATHWAYS OF PESTICIDE MOVEMENT FROM THE LAND
Persistent, soil-bonded pesticides are most readily moved from the land with run-off and erosion, particularly in the winter half year.

Harvesting of crops in that period results in soil damage from vehicles and foot traffic, encouraging run-off and erosion. This is particularly so under daffodil, broccoli and cabbage crops. Preparation of land for early potatoes in mid-winter also predisposes the land to erosion. In most fields all of these crops (normally grown in ridges) are planted up and down the gradient, further encouraging run-off.

Some instances of soil losses and run-off from former bulb fields, now in leys or cereals were also identified.

Enhancement of aldrin and dieldrin residues can take place both in redeposited colluvial soil and in run-off.

RECOMMENDATIONS
Recommendations stemming from this work are as made in the preceding work in the Hayle catchment. They are as follows:

Land management and protection against future pollution Land management of aldrin-treated fields, particularly riparian ground and steep slopes, must aim to avoid run-off. The continuous cover afforded by established grass is the best way of achieving this.

Daffodil and arable fields should be managed to avoid turbid run-off and erosion. Working and ridging, particularly final passes, should be along the contour. Where this is not possible daffodil and potato furrows should contain stop or tie ridges across them. On daffodil fields cover crops can provide

substantial protection as an alternative. Slurrying of the soil on headlands by frequent tractor traffic should be avoided.

Built up colluvium at the bottom of arable fields should be redistributed on the field. This lessens pesticide concentrations and prevents run-off overtopping lower hedgbanks. Gateways and gaps in contour aligned hedgelines should be stopped to prevent run-off leaving or entering the field. In places barriers may be needed between fields and watercourses, for the same purpose.

Advice should be given to farmers and growers on appropriate land management.

Risk evaluation The characteristics of the land in aldrin-treated fields likely to contribute to pollution risk should be stored in a geographical information system. There, using the erosion run-off risk assessment scheme, it can, with up-to-date land use information, be used to highlight pollution risk from such fields.

Monitoring of pesticide residues in water and soil Pesticide residue movement in soil water should be monitored in both freely drained and poorly drained soils by suction sampling at depth. This is particularly necessary when land use results in turbid run-off from the land.

Land drain discharge should be similarly examined along with measurements of flow.

Movement of aldrin residues in run-off from established grassland on treated fields should be measured.

Measurement of both concentrations and volumes (by flow) of residues in run-off from daffodil or arable fields is needed.

Stream water sampling should be upgraded and be event related. Flow measurement should be included.

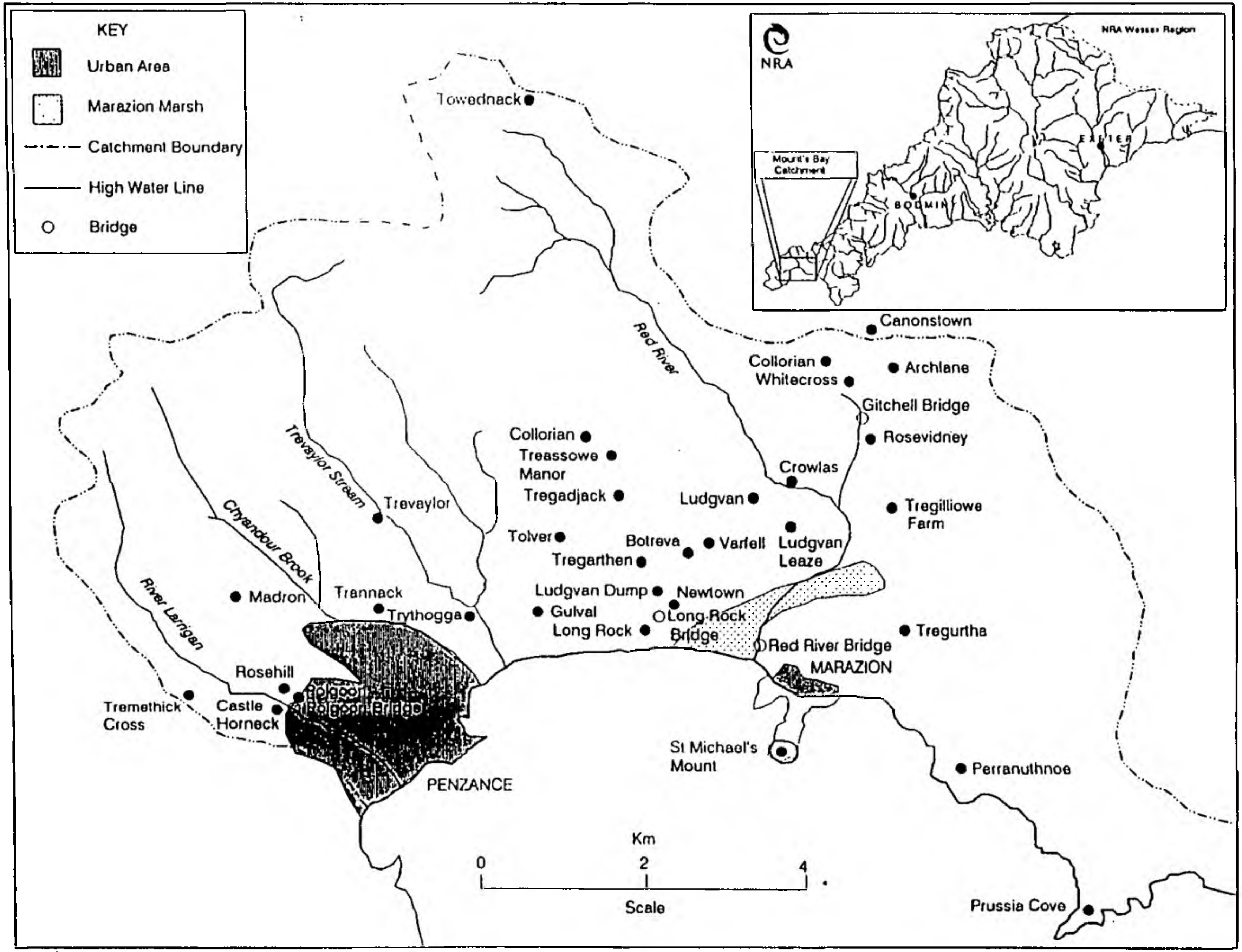
There should be systematic checks of colluvium in aldrin treated fields to assess residues.

Others The recommended land management practices should be overseen to check their implementation and effectiveness.

Research into mechanisms which apparently concentrate pesticide residues in transport should be carried out.

Work prior to pesticide registration should consider the field and environmental contexts of their practical use.

Figure 1. Location of Mount's Bay Catchment



NRA South West/March 1992

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Introduction

This study has been concerned with land use in the Mount's Bay basin of West Cornwall. The basin comprises drainage of the River Larrigan and eastward to include the Red River system, as well as that entering the English Channel as far east as Prussia Cover. In many ways the work complements preceding work in the Newlyn Coombe (Harrod 1989) and Hayle (Harrod 1991) catchments. Much of the land use takes advantage of the very mild local climate, with specialised horticulture and arable farming of some importance. There has been a long tradition of daffodil growing in which post-war intensification has brought about the use of the persistent pesticide aldrin, with consequent pollution risks.

Land use practices were determined by interview at arable farms and many grassland holdings in the catchment, along with pesticide use. Farmers renting land within the basin were also interviewed. The interviews were carried out between January and May 1991. In addition, appropriate fieldwork and sampling to determine pesticide movement from the land was undertaken, within the constraint of resources available for these activities and for analysis of materials. These aspects of fieldwork were largely undertaken between December 1990 and May 1991.

Particular emphasis was placed on the application of aldrin to land in this district, mainly for daffodil husbandry. The co-operation, openness and concern over pollution among the majority of farmers and growers noted in preceding studies at Hayle and Newlyn must be recorded once again. Use of pesticides and other agrochemicals ranges from little or none on some livestock holdings to some where use is systematic and routine. Many farmers do not fully appreciate the persistence of aldrin and its residue, although most, but not all, have a cautious attitude to pesticides as a whole.

Coupled with experience in the Newlyn and Hayle areas the fieldwork enabled a good understanding of movement of residues to water from the land to be obtained. To clarify likely sources of pesticide pollution within the catchment and related pathways and transport mechanisms, the programme of sampling and analysis, outlined below, was devised. It was intended to complement field observation of movement of soil materials across and from the land and to watercourses, following the survey of farming, land and pesticide use.

In this catchment, over 180 fields are known (Table 2) to have had at least one aldrin treatment over the past 25 years or so. Work in the Newlyn and Hayle area (Harrod 1989 and 1991) showed several pathways for movement of these organochlorine residues and it was intended to confirm or elaborate on them around Mount's Bay. In addition, it was hoped to examine further a small sample of other commonly used pesticides, to determine whether processes similar to those transporting aldrin and dieldrin were operating more widely.

The programme required sampling of soil, sediment and water directed toward a number of objectives:

a) by soil and sediment sampling

- to assess overall levels of aldrin and dieldrin in treated fields

- to determine the circumstances of movement of residues across and from the land. This would include sampling and examining the possible localised concentration of residues during transport.

b) by water sampling

- to examine water and sediment movement from the land to watercourses, including measurement of concentrations of residues and soil materials and materials and of rates of flow at selected sites, where run-off and erosion were taking place. From these, broad indications of volumes entering watercourses were expected.

From the dozen or so pesticides regularly used on daffodils (other than aldrin) and their degradation products, simazine and carbendazim (applied either directly as carbendazim or as benomyl from which it forms) were chosen for examination as indicators to test wider movement of residues. These choices were made after consultation with the MAFF Pesticide Safety Division, Harpenden.

This report largely reinforces the generalisations that could be made from the Newlyn and Hayle catchment studies, while adding some elaboration.

Several recommendations and conclusions made there, whereby land can be managed to minimise pollution hazard, are endorsed.

The co-operation and interest of the many farmers and growers from the catchment is gratefully acknowledged. The assistance and encouragement of colleagues, in particular S Bird, Mrs J Dunstan, J M Hollis, Mrs H Roberts, Mrs C M Scott and T R E Thompson also made the work possible.

P Hamey and T E Tooby of the Pesticides Safety Division of MAFF are thanked for their advice on choice of non-organochlorine pesticides for analysis.

While a number of photographs were obtained in the course of this study, illustrating the processes described, they largely repeat themes depicted in the work on the Newlyn catchment (Harrod 1989) and are not reproduced here. Video recordings of land use and run-off and erosion were obtained during the work.

The Land

The catchment is a mixture of rolling slate country and granite hills and low upland rising from sea level to almost 250 m O.D. near Towednack. The slate outcrop is diversified by sporadic outcrops of pillow lavas (Greenstones) north of Marazion. Steep slopes are confined to strips along some of the main valleys. Past metal mining has left numerous scars with several large dumps and engine houses, while floodplain alluvium has been widely worked too.

CLIMATE

The climate is mild and moist with local variation in temperature and rainfall caused by altitude and distance from the sea. Annual average rainfall is about 950 mm around Marazion but rises on the high ground north of Madron to approach 1200 mm. The pattern of mean monthly rainfall is cyclical, June being the driest month on average and November the wettest.

Winters are mild, particularly on lower ground close to the sea, and the growing season there is very long. Further inland and higher up the growing season is a little curtailed.

Sunshine incidence, which is enhanced by the near-coastal location of the catchment, is among the highest in the country. However, except in the valleys, exposure to gales is pronounced.

SOILS

The land east of National Grid 1 km easting 50 and north of northing 30 is covered by the soil survey of the Hayle sheet (SW53) (Staines 1979). Much of the slate outcrop which dominates the area is covered by soils of the Denbigh series, (typical brown earths), brown medium loamy soils over slaty rock or head. These soils occur over a wide variety of landscape facets, on extensive gently sloping interfluves, steeper valley sides and rounded ridge and spur tops. Shallow profiles are found on a few convex slopes and ridge crests. Wetter, more mottled soils occur in receiving sites and around broad valley heads, and a gradation in the intensity of gleying is recognized from Denbigh through Ivybridge to the Yeollandpark series (Staines 1979). There are medium loamy brown podzolic soils of the Manod series differing from Denbigh series in having brighter subsoils. There is a broad relationship between increasing rainfall amounts across the area and the proportion of brown podzolic soils.

Greenstone (dolerite and basalt) outcrops as patches, particularly in the northeast, and supports medium loamy typical brown earths of varying depth of the Trusham series.

Granite outcrops in the north west. Most of the lower, gently undulating and enclosed granite country is occupied by brown podzolic soils of the Moretonhampstead series, light loamy soils with brightly coloured subsoils. Higher up, on moorland or recently reclaimed land, wetter soils with humose topsoils and gleyed subsurfaces, the Hexworthy and Rough Tor series are important. These can be bouldery locally. Some of the land in broader valleys and valley heads is occupied by wet, mottled soils with humose surface layers, the Laployd series, with smaller areas of peat.

In a zone up to 2 km wide following the coast, long-term addition of composted sea sand, seaweed and town waste has produced the highly valued man-made soils of the "Golden Mile". These comprise the coarse loamy Ludgvan series with thick dark topsoils and Denbigh and Ivybridge soils with thinner, less modified tops.

Along many valley floors narrow alluvial strips have very complicated soil patterns caused by mining activity.

In several places the alluvium has had considerable contributions of material from ore crushing plants, giving fine sandy layers or thin bands of red silty `slimes' near the surface. Swamp conditions are common in these alluvial tracts, especially where humose and peaty soils occur, whilst some open water is found where ponding takes place.

Many of the alluvial tracts are in willow scrub, rough woodland or on the wetter ground covered by reed swamp (*Phragmites australis*). Some small alluvial strips are under permanent grassland, but the extent of these reclaimed areas is limited.

Mine dumps, a relict of nineteenth century mining activity, abound in the district. They are often bare or only support sparse heathy vegetation and are likely to have a large heavy metal content.

LAND USE

Although grass is easily the most extensive crop in the catchment (Table 1), there is considerable diversity of farming, with a scatter of very small scale horticulture too. Land use varies from farms given over to grassland, usually for cattle, through mixed enterprises, to those which are largely involved with field vegetables, principally broccoli (winter cauliflower), cabbage and potatoes. Daffodils are grown on a number of holdings, both on rented ground and on land owned by the growers.

Permanent pasture, often in very small fields, is most extensive on the higher land in the north. Most of the grassland supports either dairy or beef cattle, there being only 5 small permanent flocks of sheep in the catchment. At lower altitudes nearer the south coast, the grassland is more usually part of a rotation with cereals, and on a large number of farms climatic advantages are exploited in cash crops. Within a mile or so of the coast is the "Golden Mile" between Marazion and Penzance, with field vegetables and horticultural crops grown, with double cropping on many holdings.

Over the southern part of the catchment brocccoli, spring cabbage and potatoes are grown in rotation with leys and cereals. This reflects the rotational needs of the broccoli crop: apart from on man-made Ludgvan soils on the Golden Mile, it is not widely grown more often than one or two years in six, the leys being down for at least 3 or 4 years. In favoured sites where high pH is either a natural property of the man-made soils, or where it is maintained by heavy dressing of calcareous sand, almost continual double cropping of broccoli and cabbage with other cash crops, including potatoes, is commonplace. Elsewhere the rotation usually begins with pasture being broken for an early potato crop. Once this is lifted the ground is prepared for planting of broccoli or cabbage in July, which are harvested through the winter, to be followed by spring-sown cereals or another potato crop, sometimes followed by a second broccoli or cabbage crop. Reseeding to pasture takes place around the third year.

Broccoli has been an important crop in climatically favoured areas of the south-west for over a century. The necessity of winter harvesting means that the widespread well drained soils in this district are suited to broccoli cultivation. Seed is sown in nursery beds in early May (although the biggest single grower brings in plants from Lincolnshire) and the plants set out by planting machines in the summer; in exposed sites they are commonly banked up to avoid excessive wind damage; ridges, along with most other cultivations, being most commonly aligned up and down any slope.

Where club root is a risk, plants are dipped in pure calomel mixture before planting and organophosphorus insecticides can be applied at planting (in the past aldrin was used on some holdings) to control cabbage root fly.

Harvesting is by hand and begins in October continuing with successional varieties until May. The cut heads are collected in trailers (some specialised for the work) or tractor mounted bins as the cutters move through the crop. The crop is graded on the field or in packing sheds and packed for despatch to the national markets.

Early potato production is carried out in the most favoured sites along the Golden Mile. There is a trend elsewhere towards second early and maincrop potato growing to supply crisp manufacturers and the demands of the holiday trade. Most farms are equipped with de-stoning equipment, mechanical planters and complete harvesters for handling the crop. Early crops are planted in January or February and growth encouraged by covering the ridges with perforated polythene, which once the plants are well in leaf, is removed. Invariably ridges are drawn across the contour on sloping land since otherwise machinery is difficult to operate. Harvesting is under way by May for first earlies and continues into late summer for maincrop and crisp potatoes.

Climatically favoured areas of west Cornwall are ideal for early bulb flower growing in the open. Traditionally production has been on a small scale for blooms, with flowers harvested between December and March, the bulk being picked in February. In the last twenty years production has become intensified and mechanised with fewer growers operating on a larger scale and with the added interest of bulbs being produced for sale, with many exported. Flower buds do, however, remain the most valuable part of the crop. Narcissus is grown as a biannual crop planted in ridges in late summer, flowers being harvested in both years, after which the bulbs are lifted and graded in June and July. To avoid bulb eelworm infection a break of 7-8 years is advisable between crops which can necessitate the renting of land from neighbouring farms.

As with other row crops efficient operation of planting and lifting machinery is only considered feasible where ridges run up and down the slope. The flowers are picked by gangs of casual workers who bunch the flowers with elastic bands. They are then carried to the headlands for boxing and collection by tractor prior to packing for despatch.

The farming system and the mild, moist climate of the district does not favour large scale cereal production and only a few farmers grow grain for sale. Most of the modest acreage (dominated by barley) is for feeding on the farm, cereal crops widely forming part of the rotation with grass, potatoes and brassicas. For this reason spring-sown cereals are more commonplace than in much of the rest of the country. Table 1 summarises the approximate areas of crops and other forms of land cover in the catchment which covers around 7,400 ha. Many farms have land extending beyond the catchment so that year to year figures will vary, while double cropping of potatoes and broccoli also complicate matters.

Table 1 Land cover, approximate area in hectares

		ha
Grass		2700
Bulbs		125
Potatoes		480
first earlies	455	
for crisps	20	
maincrop, etc	5	
Broccoli		490
Cabbage		235
Cereals		610
Spring sown (mostly barley)		480
Winter sown (mostly barley)		120
Forage crops		110
Woodland and scrub		110
Reedbeds and open water		50
Rough grazing and moorland		580
Urban		260

Scattered around the catchment there are many small growers, some using polythene tunnels or glasshouses, in total occupying a few tens of hectares, producing a range of vegetables, salad crops, soft fruit and flowers. These include swedes, carrots, parsnips, broad and green beans, calabrese, courgettes, asparagus, lettuce, peppers, tomatoes, cucumbers, raspberries, strawberries, anemones, kaffir lilies, pinks, sweet williams and violets.

In addition to agricultural land there are strips of woodland in some valleys, where traditional deciduous woodland, often oak dominated, has been partly replaced by conifers. On the higher ground, on steep valley sides and around old mine workings, moorland, heath and scrub provide rough grazing. The *Phragmites* marsh SSSI at Marazion, along with associated open water and Long Rock Marsh, form habitats of some national importance. Elsewhere valley bottom alluvium has been disturbed by tin workings with pools and areas of willow and alder scrub.

Pesticide Use

The survey of land use practices outlined in the introduction is the basis for this summary of pesticide use in the Mount's Bay catchment.

Insecticides

Aldrin Recent registered use here of aldrin (Aldrex 30, Aldrin 30) (29.1% aldrin by weight) prior to its withdrawal in June 1989, has been limited to the control of narcissus fly in bulbs. Application was made to the soil around the bulbs immediately prior to ridging by a spot sprayer on the planting machine at 9.1 litres per hectare (although land at Castle Horneck and Trevaylor is understood to have received only 4.1 litres per hectare). Formerly it was applied by boom sprayer to all the soil at rates of around 27 litres per hectare according to some farmers (and before that broadcast as a dust) and worked in. Elsewhere this method remained in use for wireworm control on old grassland broken for potatoes, although no evidence of the practice was found in this catchment.

Withdrawal of aldrin has left bulb growers in need of a replacement. Currently carbofuran (Yaltox) granules applied to the soil are used. However, it is not regarded as being as effective as aldrin and is shorter lived in its effect.

Broccoli and cabbage plants have been dipped in an aldrin suspension on many holdings, the practice continuing until the withdrawal of aldrin on a few. Some land has received aldrin dust prior to planting anemone corms. In the earlier years of its use aldrinated fertilizers were available at a slight premium, although this ceased following the Cook (1964) review of the persistent organochlorine pesticides. Prior to that aldrin and dieldrin were used in root fly control on nursery beds for broccoli and cabbage.

Other insecticides are used for root fly control in broccoli and cabbage seed beds, which are of about 10% of these crops' total acreage. Directly drilled seeds (particularly cabbage) are usually dressed with gamma HCH (Gamma-Col) against root fly or when necessary with captan/gamma-HCH (Gammalex) against flea beetle. Control is also by way of dips or the planting machine in the field crop. Carbofuran (Yaltox), dimethoate (Rogor), chlorpyrifos (Dursban) and Jeyes' Fluid are also used. Yaltox is also occasionally used for stem weevil. Generally other insecticides are only applied to planted-out crops when there are serious attacks by aphids, when Aphox (pirimicarb) or dimethoate are used, or by caterpillars which are combatted with cypermethrin (Ambush), deltamethrin (Decis) or Aphox. Several of these insecticides are also put on for aphid control on potatoes, cereals and flowers, such as anemones and pinks.

Cereal seeds are dressed with insecticide (often lindane (gamma-HCH) based, such as Gammacol) before sowing on some farms. Dressed seed is either bought in from the seed merchant or prepared on the farm. In some instances dressings are combined fungicides and insecticides, such as Mergamma (gamma-HCH + phenylmercury acetate).

Herbicides

The daffodil fields are sprayed with paraquat (Gramoxone), glyphosate (Roundup) or diquat + paraquat in the autumn before bulbs emerge. The most extensive growers also apply simazine on bulbs in the autumn or early winter after planting. Similar treatments are used in the spring on fallow after the bulbs have been lifted to eliminate keepers. Residual herbicides including Profalon (chlorpropham + linuron), C.I.P.C. (chlorpropham), linuron and lenacil + linuron, are sprayed in December, with C.I.P.C. reapplied in January by some growers.

On potato land weeds are controlled using pre-emergence herbicides including monolinuron (Arresin); monolinuron + paraquat (Gramanol), terbuthylazine + terbutryn (Opoguard) and propachlor (Ramrod). Linuron + trietazine + trifluralin (Pre-Empt), metribuzin (Sencorex) and sodium chlorate (Centex) have limited use.

Gramoxone, trifluralin (Treflan, Tristar) and propachlor (Ramrod, Albrass) are commonly applied for weed control in broocoli and cabbage seed beds and in turnip, mangol, swede and fodder beet fields, with a few farmers preferring glyphosate, desmetryn (Semaron) or chlorthal-dimethyl + propachlor (Decimate). Ethofumesate (Nortron) and phenmedipham (Betanal E) are sprayed on fodder beet.

On cereals a variety of herbicides are sprayed, on some farms routinely, on others only to deal with a specific problem. Stubbles may be cleaned with glyphosate (Roundup) or paraquat (Gramoxone). Pre-emergence herbicides applied include Pre-Ept (linuron + trietazine + trifluralin) and Chandor and Warrior (both linuron + trifluralin). Among contact and residual preparations used are Ally (metsulfuron-methyl), Panther (diflufenican + isoproturon) and Swipe (bromoxynil + ioxynil + mecoprop). Post-emergence treatment by Banlene Solo (dicamba + MCPA + mecoprop) MCPA, Legumex Extra (benazolin + 2,4-DB + MCPA) (for use on undersown crops) and Deloxil (bromoxynil + ioxynil) is used at various farms.

Some of the above include Legumex and MCPA as spot treatments on established pastures, along with Asulox (asulam), Grazon 90 (clopyralid + triclopyr) and Docklene (dicamba + MCPA + mecoprop).

On the very limited areas of other crops the following herbicides have been used. Linuron on carrots and parsnips, various pre-emergence sprays on lettuce beds, tank mixtures of Roundup with the fungicides Rovral (iprodione) and Elvaron (dichlofluanid) on strawberries, Sinbar (terbacil) on strawberries and anemones, simazine, Muster (glyphosate) and Parable (diquat and paraquat) on asparagus and Lanslide (lenacil + linuron) on gladioli.

Fungicides

Lifted bulbs are dipped in 2% formaldehyde and certain varieties are treated with thiabendazole (Storite). As flower buds develop narcissi receive mancozeb (Dithane) with benomyl (Benlate) or carbendazim, on occasions as a tank mixture, as 4 or 5 applications in late winter. The most extensive grower also uses vinclozolin (Ronilan). Rovral and Benlate are also applied to anemones. The principal fungicides used on potatoes for blight control are mancozeb (Dithane), mancozeb + metalaxyl (Fubol) or manganese zinc ethylenebisdithiocarbamate + ofurace (Patafol Plus). Benalaxyl + mancozeb (Galben), fenpropimorph + prochloraz (Sprint) and fentin acetate + maneb (Brestan) are also used for blight control, but less extensively. Brestan has the advantage of shorter delay time between spraying and harvesting. Brassica seeds are dressed with combined fungicide and insecticide Gammalex (captan + gamma-HCH) before sowing. When required broccoli and cabbage seed beds may be sprayed with Fubol or Bayleton (triadimefon) to contain mildew. In planting out from the seedbed plant roots are dipped in calomel to control clubroot on susceptible land. On some farms pH is maintained at a high value by use of Hayle sand as an effective control of this disease. Systemic fungicidal cereal seed dressings are used on some farms. Tilt (propiconazole) is sprayed on cereals for mildew control, with Hispor (carbendazim + propiconazole), Sportak (carbendazim + prochloraz), Radar (propiconazole) and Dorin (triadimenol + tridemorph) also used.

A wide range of fungicides are used on very small scales by growers of flowers, salad crops etc, some of which are protected under glass or polythene. Included are Benlate, Fubol and Rovral on runner beans, lettuce, pinks and other flowers, tomatoes and strawberries, Captan on flowers, Dithane and Ronilan on asparagus.

Sheep dips

Compared with more easterly parts of the county there are very few sheep in the Mount's Bay area, with 5 permanent flocks, 2 of them of 30 animals or less at present and the others between 100 and 200. There has been little interest among local farmers in sheep although the introduction of milk quotas may change matters. Winter grazing is let on one farm with 115 sheep brought in for a few weeks. Sheep dips currently in use have been identified at 518341, 555282, 46683407 (no longer used) and 48933835. Spent dip is disposed at each of these onto the nearby soil. As well as by the farmer's own sheep, some dips are used by neighbours, some with temporary flocks, particularly that at 48933835, where up to a thousand animals are treated. One flock is taken out of the catchment when dipping is required. A mobile dip is used for 190 sheep at 476336. The dip at 48933835 is a mobile structure normally used at that site, which is very close to the catchment boundary.

Other animal health products are used, particularly for lice and flies on housed cattle and for warble fly. These include fenthion (Spotton), Gamma-HCH (both as nationally available products and local chemists "own brand" preparations), phosmet (Poron) and ivermectin (Ivomec). Amounts used appear to be generally very small, for example 1 kg of louse powder lasting a few years, with many farms not having call for their use. However, a lack of appreciation of veterinary products as pesticides was apparent among many farmers.

Other uses of pesticides

The wide range of pesticides used in agriculture and horticulture is described above. Part of this report is given over to the examination of ways in which acceptable use of pesticides can, in normal practice by farmers or growers, lead to serious risks of water pollution. Consideration of their irresponsible use or disposal is beyond the scope of this work, but it cannot be discounted in considering pollution risk. Furthermore the wide non-agricultural use of pesticides, by both professionals and amateurs, must not be overlooked. It is commented on in the Hayle basin report (Harrod 1991).

The widespread use of aldrin in this catchment can be gauged from Table 2 and concern that its persistent residues might be involved in pollution is the justification for this study. The work has produced findings broadly similar to those described in the report on the Coombe/Newlyn River (Harrod 1989) and the Hayle basin (Harrod 1991) with some supplementary information. Comments from them are reiterated concerning pathways, not only from the standpoint of aldrin and dieldrin, but from that of other insoluble pesticides and agrochemicals which may be bound to soil particles.

Those reports provide description of application methods and rates, while part of the Hayle study examined degradation rates of aldrin and dieldrin, to which the reader is referred.

Table 2 Fields in the Mount's Bay catchment to which aldrin is known to have been applied

National Grid Reference (SW)		Year of Application	Comment
			(* - Field abuts valley bottom or floodplain)
Collorian	525348	1987	
	527349	1987	
	527347	1987	
	526353	1988	
	527351	1987	
	528350	1987	
Rosevidney	534346	1988	
	534345	1988	Riparian
	533343	1988	Riparian
	535344	1988	
	536377	1988	
	531333	1985	
	530331	1985	
	530337	1982	Riparian
	531335	1982	
Varfell	50303210	1980	
	50353215	1978	
	50303225	1978,88	
	50303230	1978,88	
	50383227	1978	
	50383235	1978,87	

Continued.....

Table 2 Continued

Varfell continued	504321	1978	
	504322	1978,88	
	505324	1988	
	506329	1979	
	506320	1979	
	50553220	1982	
	50583233	1987	
	50553250	1988	
	507320	1982	
	507321	1982	
	507323	1981	
	507324	1988	
	507325	1988	
	507326	1980,88	
	507327	1988	
	507328	1985	
	509320	1982	
	511319	1982	
	510320	1982	
	509321	1984	
	509322	1978	
	509324	1984	
	509325	1983	
	509326	1987	
	508327	1986	
	507328	1985	
	509327	1986	
	508328	1984	
	509329	1988	
	509330	1988	
Perranuthnoe	546295	1979	
	549298	1979	
	548297	1979	
	55292943	)Aldrin applied c. 1985 to	
	55252924	)to very small beds (each	
	55292920	)only a few tens of	
	55332930	)square metres)	
Trannack	464317	1981	
	465318	1981	
	465319	1981	
	466319	1983	
	467318	1983	
	468318	1979	Moderate slopes
	471315	1979	Steep slopes, riparian
Trythogga	475316	1979	Some steep slopes
	47553150	1979	
	476314	1979	

Continued.....

Table 2 Continued

Trythogga continued	476313	1979	
Polgoon	457309	1974	
	458306	1971	
	459307	1971	
	459308	1974	
	45903045	1970,73,87	
	45973050	1970,76,82	
	460306	1971,87	
	46003040	1984	Steep slopes
	460307	1974	
	46053043	1973,84	
	46653035	1971,76	* Mostly taken for A30
	46633044	1976,83,87	Steep slopes
	46043045	1973,84	Moderate slopes
	46063050	1971,87	Moderate slopes
	461305	1975,80,85,87	Moderate slopes
	467305	1970,73,85	*
	466306	1975,87	
Tregarthen	50243180	1982	Partly taken for A30
	50203200	1982	
	50163210	1982	
	496328	1984	
	496326	1984	
	497327	1984	
	497328	1984	
	497330	1984	
	498327	1984	
	498328	1984	
	498329	1984	
	499328	1984	
	49823245	1978	
	49833260	1978	
	49863265	1978	
	49953260	1983	
	49953275	1978	
	50003256	1978	
	50003270	1978	
	50033271	1983	Moderate slopes
Newtown	506318	1978	Taken for roundabout
	509318	1979	
	511318	1982	
Tregurtha	528310	1977	
	52903115	1977	
	52923083	1977	
	52933104	1975	

Continued.....

Table 2 Continued

Tregurtha continued	53053100	1977		
	52953114	1975		
	53003104	1977		
	52993154	1985		
	529317	1985		
	530319	1985		
	530318	1983		
	531317	1983		
	531316	1985		
	532312	1981		
	533311	1981		
	533312	1981		
	531304	1975,79		
	537308	1979		
	534320	1976		
Tremethick Cross	444305	1980,88		
	445305	1980,87		
	444309	1979		
	445308	1979		
	446308	1979		
	445306	1988		
	446307	1988		
	447306	1981		
	44803075	1982	Riparian	
	448305	1984		
	44733035	1985		
	449307	1983	Riparian	
	449304	1984		
	449302	1984		
	450303	1986		
	451301	1985		
Trevaylor	470320	1987		)
	468321	1985		)
	470321	1985		)
	46953200	1985		)
	469323	1987		)
	467323	< 1985		)
	468324	< 1985		)
	46653240	1986		) Aldrin applied
	46753245	1986		) at 4 l/ha only
	466325	1986		)
	467326	1987		)
	465326	< 1985		)
	466327	< 1985		)
	467328	1987		)
	468327	< 1985		)
	470325	1986	Riparian	)
	471324	1988		)

Continued.....

Table 2 Continued

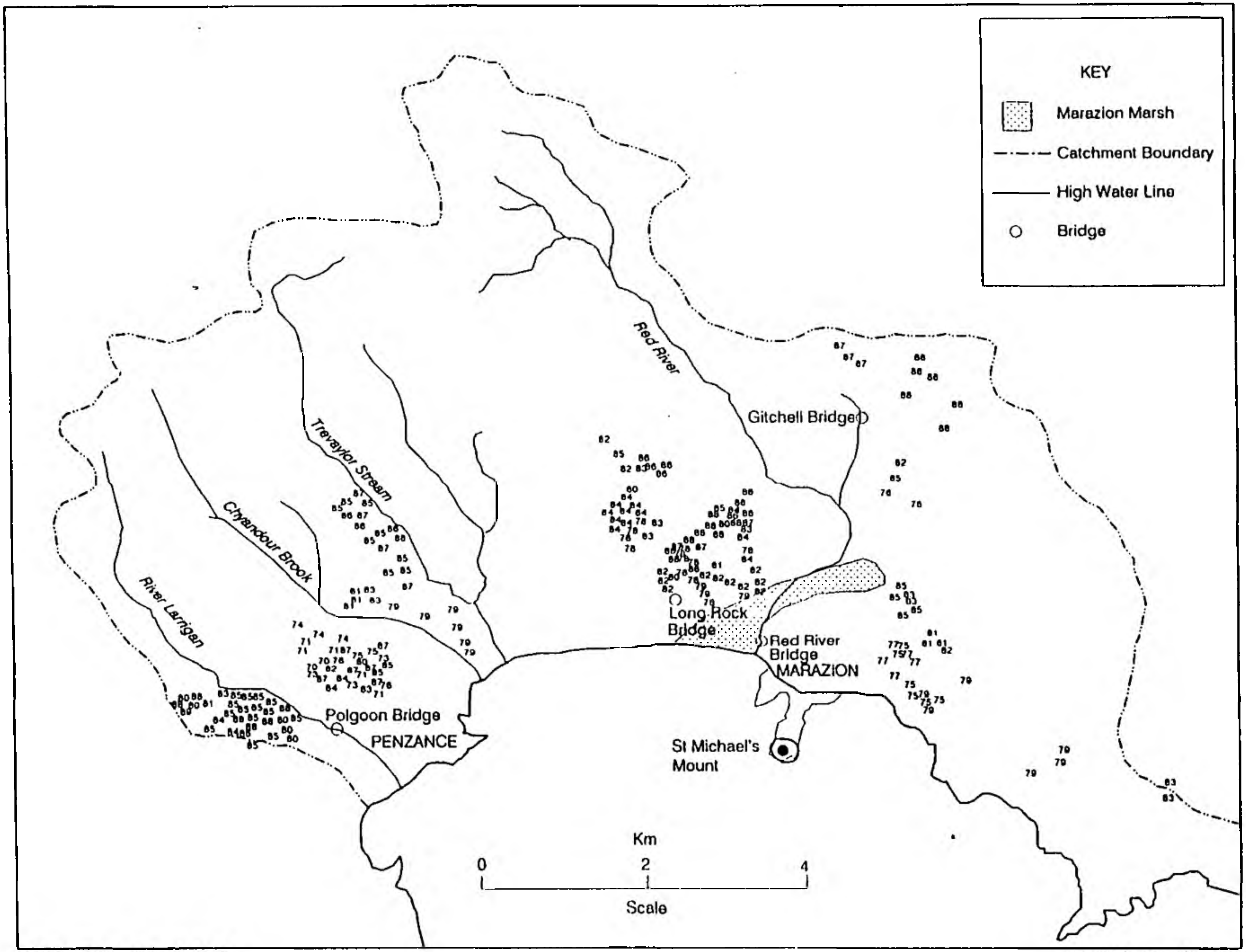
Castle Horneck	456303	< 1985	Riparian & steep slopes	)	
	45453025	< 1980		)	
	455301	< 1980		)	
	45453015	1985		)	
	45303024	< 1985		)	
	454303	< 1980		)	
	454304	< 1985		)	
	45423048	< 1985		)	
	45413053	< 1985	Riparian	)	
	45323062	< 1985	Riparian	)	
	45313053	< 1985		)	Aldrin applied
	45203044	< 1985		)	at 4 l/ha only
	452303	1988		)	
	451304	1988		)	
	45153046	< 1985		)	
	45203055	< 1985		)	
	45203065	< 1985		)	
	45133068	< 1985	Riparian	)	
	45053055	< 1985		)	
	45003045	1988		)	
	45093072	< 1985	Riparian	)	
	450306	< 1985		)	
	44953055	< 1985		)	

LAND USE, RUN-OFF AND EROSION

Examination of cropping and land use practices indicates a number of likely pathways. The infiltration of rainwater into soil is a function of rate of rainfall and the soil's porosity, both at the surface and deeper in the profile. Run-off can have a number of forms. Under some circumstances, for example surface flow from pasture, it can carry only small amounts of suspended solids. In other cases turbid run-off can discharge from the land with an appreciable suspended solids load, but afterwards lacking clear evidence on the ground of loss of soil. This condition can grade into more obvious deposition following sheet erosion, where large amounts are clearly redeposited downslope, yet without strong signs of surface soil movement at the point of loss, or at least without clear indications of the scale of movement there. Only in more acute circumstances may the surface be broken by rills, or more extremely by gullies.

The range of circumstances which dictate manifestation of these is complex. Included are environmental circumstances (soil type, slope, rainfall incidence etc) and man-induced conditions (crop types, cultivations, soil and land management and mismanagement). Many of these can interact. On naturally freely drained soils with high biological activity and in which the surface is not subjected to damage, most, if not all, rainwater infiltrates under all but the most severe storms. However, on soils of more restricted natural permeability, or on those suffering surface puddling, smearing, capping, wheeling or poaching, infiltration rates can be drastically curtailed. These forms of soil damage are particularly associated with crop harvesting or management during the winter half year (field capacity season)

Figure 2. Dates of Aldrin Application



NRA South West/March 1992 wqp/bs/general/mount2 that is commonplace in this district. As well as involving daffodils, winter-harvested broccoli and cabbage crops also encourage soil damage, as does winter preparation and use of land for early potatoes. The practice of double-cropping is likely to result in soil structural degradation, leaving little margin of error for timeliness of cultivation.

Harvesting of the daffodil flowers demands daily foot traffic by the pickers between the ridges in which the plants grow, at a time when the soil is at the best moist, and often waterlogged. This inevitably puddles and compacts the topsoil and reduces infiltration. At the same time frequent tractor traffic (often several times a day) along the headlands to collect the picked flowers for packing, ruts the ground and in wet weather creates a slurry of soil and rainwater.

In wet weather attenuated infiltration results in enhanced run-off, which can be very severe on the wetter soils, along the furrows (usually aligned up and down the slope). In many places this run-off is sufficient to cause some saltation or suspension of soil material, as testified by small flow marks on the surface or small patches of water-sorted soil. This passes downslope with the water, some of the moved soil material being concentrated on the downslope headland where movement continues along the ruts left by tractor traffic. On many fields the movement of soil appears more severe on alternate furrows, suggesting that the passage of tractors along them has an effect on run-off.

Once on the headland the load of soil in the water increases rapidly, both due to the slurry-like state of the ground after repeated wheelings and to the concentration of water from the upslope furrows. At the lowest point puddles or pools form in which some of the sediment is deposited. Locally within the field, where the configuration of the ground is such as to check the flow of water in the furrows, it can form puddles which, as they overtop the ridges, provide sufficient erosive force to breach the ridges for tens of metres, carrying soil from the ridges downslope and producing rills in the ground. Once dispersed into a slurry, redeposited soil material requires a period of drying before the process of ripening, consolidation and re-aggregation can take place.

The consequence of these processes is that the load of soil material may be deposited as sorted or bedded colluvium at low points on the headland (often very close to a watercourse), may move across adjacent downslope fields, at times picking up more soil and pesticides, or directly enter ditches or streams along with the water carrying it from the field. Depending on conditions in the watercourse, any sediment reaching it will be deposited on the stream or ditch bed or carried away. Clear evidence for deposition on the headland can be short-lived since depositional structures are often destroyed by the next tractor traffic. Estimation of quantities involved is therefore difficult.

There is strong anecdotal support for this description of soil and run-off conditions in bulb fields from farmers, farm workers and local residents. Many can point to instances in the past where run-off has gathered and passed across fields (including pasture) or down roadways (on occasions eroding these) to drains and watercourses, and, in places, to flood properties.

As well as sampling water running off the land in these circumstances and rates of flow, soil samples (Tables 3, 10 and 11) were taken and confirm this interpretation. Photographic and video recorded evidence were also obtained.

Other crops are grown using ridges. As well as potatoes many brassica crops in this district are grown on ridges. Potato fields are generally worked down in winter and spring to very fine tilths, commonly being de-stoned/de-clodded to facilitate harvesting and to avoid damaged or mis-shaped tubers. On sloping land the ridges are invariably directed along the steepest gradient in the field and in many seasons result in "washes" of soil accumulating at the downslope end of the field, often with recognisable rills formed in the furrows further upslope. Whether polythene cover accentuates erosion is uncertain, although often only the alternate furrows, which remain bare, appear to suffer rilling. The opinion among some farmers and growers using it appears to be that it checks run-off and erosion. However, this pattern of rills in alternate furrows appears on some fields without polythene and may be encouraged by de-stoning or compaction beneath tractor wheelings. Also observations made in this survey show accentuated erosion when polythene was used. Again, different circumstances of soil conditions, rainfall intensity etc, may have different erosional consequences.

The combination of direction of working and fine tilths seems predisposed to erosion, however other factors such as gradient and intensity of rainfall, crop cover and the state of the soil and its surface must also be considered. Given a period of dry weather after ridging, or weather with only light rain, the soil has time to settle. If it is only slowly moistened it can partially coalesce, recovering some coherence which will better resist erosion. The production of a slaked cap can also offer modest resistance provided it has time to develop polygonal cracks which will form routes for infiltration. However, if heavy rain follows ridging up (or the application or removal of the protecting polythene) erosion is very likely to occur.

On sloping land other row crops, such as broccoli and spring cabbage, tend to be planted following the slope. For cereals or new leys direction of working, not being dependent on precision machinery, is less critical. However, many fields have their long axes aligned with the slope, encouraging cultivations, including final rolling or top dressing, that way. In consequence erosion can be a risk there if erosive rain occurs before consolidation of the soil or development of the crop cover.

Although direction of cultivation is less critical to operations for cereal growing and reseeding of grass, field shape and custom dictate that these crops are usually sown across the contour. This maximises the risk of rill and gully erosion. In 1991 erosion of winter cereals, the most extensive arable crop in the district, was recorded in several fields, two of them aldrin-treated. Accumulation at the foot of the field from the rills took place as small cones. There were also indications of capping of the soil and possible losses by sheet erosion from part of the field.

Table 3 gives an indication of the scale of run-off from a range of crops. Measurements were carried out under warm frontal conditions, when falls might be expected to be most uniform spatially (allowing rainfall data from the nearest autographic raingauge at Drift Reservoir to be referred to with confidence). These conditions were also favoured since they could be expected to persist for a few hours. On each occasion quoted precipitation at Drift was at a very uniform rate. The preceding 20 hours on 22nd February was rain free, on 15th March there were two dry days before and on 18th March the last previous rain was that of 15th.

While standard statistical analysis of rainfall data allows estimation of return periods of heavier precipitation, return frequencies of rates of around 2 mm an hour are not available. However, examination of long-term statistics for Drift 1962-91 show that falls in excess of 10 mm per day occur on average 24.5 times per annum for the October to March period, suggesting a return period of around 2 weeks for such commonplace and unexceptional rainfall.

The modest effect of such rainfall on the streams is indicated by flow in the Red River's tributary at Gitchell Bridge on 22nd February and 18th March, which increased from a base of about 0.04 m^3/sec to 0.10 and 0.15 m^3/sec respectively at about the end of the rain.

In several instances the run-off measured was associated with substantial suspended solid loads (see Table 4) either at the sampling site or lower downslope. An example of the latter circumstance is comparison of suspended solids of run-off leaving Longlane field (508325) which then passed down wheelings and tracks and across land in broccoli (treated with aldrin in 1988) for about 600 m to the Varfell sampling point at 506321, before it entered the highway drainage system and eventually through that the Botreva Stream. Between these two sample sites suspended solids changed from 148 mg/l to 8,000 mg/l without any increase in discharge.

Amounts of soil material lost from fields as suspended solids during the sampled events of 22nd February, 15th and 18th March listed in Table 3 were generally modest (Table 4) at a few kilograms per hour. However, the amounts of colluvium deposited in lower parts of fields and beyond suggest that under the heavier rainfall conditions, which may occur only a few times a year, erosion can be more severe. Under such circumstances suspended solid and pesticide residue amounts entering watercourses from the land may be substantially greater.

The local circumstances instigating erosion and the subsequent transportation and redeposition, both to and in watercourses or on lower ground are diverse. These frequently lead to substantial disparities between observed erosion and deposition. In many instances this must be accounted for as loss, particularly of finer fractions to watercourses or to lower sites.

Table 3 Measured run-off from fields

Crop/Site	Date/Time/Amount of run-off					
	22/2/91 (Rainfall 1015-1600 2.3 mm/hr*)		15/3/91 (Rainfall 0445-1000 1.4 mm/hr*)		18/3/91 (Rainfall 0620-1315 2.5 mm/hr*)	
DAFFODILS	time	mm/hr	time	mm/hr	time	mm/hr
Playing Field[1] (512329) 1.3 ha	1600	**0.22**				
Tollhouse[2] (508233) 1.2 ha	1430	**1.44**				
Longlane[2] (508325) 2.0 ha	1400	**0.70**				
Tregilliowe (531333) 2.8 ha					1030	**0.66**
CABBAGE						
Ludgvan Leaze (510327) 3.9 ha			1045	**0.17**		
Tregurtha (530317) 4.5 ha					1130	**0.26**
BROCCOLI						
Varfell (506320) 1.0 ha	1500	**0.30**				
POTATOES						
Tregadjack (493329) 0.8 ha			0935	**0.99**		
Polgoon (461304) 0.4 ha	1100	**1.43**	0830	**0.49**		
CEREALS						
Treassowe (500333) 0.8 ha			1000	**0.48**		
Tregurtha (530317) 0.8 ha					1130	**0.08**
ASPARAGUS						
Townfield[2] (504320) 2.0 ha	1630	**1.5**				
GRASS						
Trannack (463315) 0.9 ha			0900	**0.78**		
BEANS						
Polgoon (462305) 0.4 ha	1050	**1.40**				

*Rainfall at Drift (439286) [1] = Crowlas [2] = Varfell

At several sites it was clear from the nature and quantity of erosion and deposition of soil that sheet erosion was playing a considerable role. This is not readily distinguished from capping and slaking of topsoil material caused by rain impact. However, it may explain the large disparity between in-field deposition and observable erosion of other forms, as at Townfield (Table 5).

In the colluvium at Townfield there is no marked discrepancy between sorted coarse (sandy) deposits and finer (silty) sorted material (20.5 against 26.6 m^3), although

Table 4 **Rates of run-off, suspended solids and pesticide residue movement from land**

	Run-off (mm/hr)	Suspended Solids Loss (ha/hr)	Aldrin/ Dieldrin (ha/hr)	Carbendazim (ha/hr)	Simazine (ha/hr)
22/2/91 (2.3 mm/hr rain for 5.75 hrs)					
Daffodils	0.79 (0.22-1.44) (n = 3)	2.34 kg (0.28-5.34)	-	17.33 mg (3.52-43.3) (n = 3)	272.8 μg (n = 2)
Broccoli	0.3	-	-	-	-
Potatoes (no poly)	1.43	-	-	-	-
Beans	1.40	30.96 kg	30.39 mg	-	-
Asparagus	1.51	1.77 kg	3.82 mg	-	-
15/3/91 (1.4 mm/hr rain for 5.25 hrs)					
Cabbage	0.17	576 g	329 μg	-	-
Potatoes (poly)	0.99	5.64 kg	1.69 mg	-	-
Potatoes (no poly)	0.49	8.09 kg	8.59 mg	-	-
Cereals	0.48	555 g	217.2 μg	-	-
Ley	0.78	396 g	252 μg	-	-
18/3/91 (2.5 mm/hr for 7.25 hrs)					
Daffodils	0.66	-	-	-	-
Cabbage	0.26	-	-	-	-
Cereals	0.08	67.6g	74.6 μg	-	-

Means

Rain	2.07 mm/hr
Daffodils (n = 4)	0.76 mm/hr
Potatoes (no poly) (n= 2)	0.96 mm/hr
Cabbage/broccoli (n = 4)	0.24 mm/hr
Cereals (n = 2)	0.28 mm/hr

Table 5 Summary of soil erosion and deposition

Site, Grid reference and area	Soil series and slope	Erosion (m^3)	Deposition (m^3)
DAFFODILS			
Playing Field[1] 512329 2.3 ha	Denbigh* and Ivybridge* 2-4°	0.10	25.2
Tollhouse[2] 508233 1.8 ha	Ludgvan (ungleyed) 3°	1.87	7.3
Tregilliowe 532323 3.2 ha	Denbigh and Trusham 2-4°	None observed	3.0
Longlane[2] 508325 2.8 ha	Denbigh* 3°-4°	0.47	None observed
POTATOES (with polythene)			
Tregadjack 493329 0.8 ha	Denbigh 0-6°	4.0	6.4
Tolver 493322 1.4 ha	Ludgvan (ungleyed) 2-11°	88.9	Uncertain, much onto road
POTATOES (without polythene)			
Tolver 4932322 0.3 ha	Ludgvan (ungleyed) 2-11°	13.6	Uncertain, much onto road
Polgoon 461305 0.4 ha	Denbigh 2-5°	4.7	3.1
CEREALS			
Treassowe 500333 0.7 ha	Denbigh 0-6°	0.35	1.4
LEY PASTURE			
Trannack 463316 0.9 ha	Denbigh 3°	8.1	Little fesh deposition
ASPARAGUS			
Townfield[2] 504321 2 ha	Denbigh* 3°	Little recognisable	47.1

[1] = Crowlas [2] = Varfell * indicates man-made topsoil phases

(Table 4) substantial amounts of finer material are likely to be lost in run-off. At other sites there can be substantial discrepancies between quantities of sandy colluvium and finer deposits, with sandy material in a preponderance.

Playing Field (Table 5) exemplifies many fields with row crops, including in addition to daffodils, broccoli, cabbage and early potatoes. There most furrows are floored by a discontinuous, narrow wash or trail of separated sand grains a few millimetres deep and up to 5 cm wide. This has been derived from clay loam textured soil with at least a proportion of the associated finer particles (silt, clay and organic matter) in all probability being lost, suspended in run-off. At Playing Field (2.3 ha) about 10.4 m^3 of sandy material is estimated to have occupied furrow bottoms with an additional 7.9 m^3 at the row ends as mixed and interbedded sandy and silty material in small delta-like cones or fans. Run-off passing from the furrows resulted in further deposition (and a small amount (0.1 m^3) of identifiable erosion), placing around 7.3 m^3 of mostly sandy material on the headland. Water passing beyond the sandy depositional fans and from the field was turbid leaving a brown silty slick over the grass on part of the downslope sports field.

Rill erosion of the small early potato field at Polgoon amounted to 4.7 m^3 depositing 3.1 m^3, mostly on the lower part of the field. Of this all but 0.44 m^3 was sandy. There was further unmeasurable sandy deposition downslope on a track and on rough ground. Again the disproportionately large amount of sand strongly suggest that the finer soil fraction has been removed in suspension.

Run-off commonly becomes channelled and may follow dendritic rill systems, pass along furrows, headlands, tracks or roadways or flow onto ground downslope. Once this has happened it tends to stay concentrated for some distance. Also when run-off takes place from one piece of land, that adjacent tends to be already wet or waterlogged and is unable to absorb more water. Several instances supporting these observations were noted, with water eventually passing into ditches or other field or highway drains and through them into natural watercourses.

Of the 16 sites listed in Tables 3, 4, 6 and 8 run-off reached watercourses or road drains in 8, at 3 it appeared contained within the field by hedgebanks, at 3 others it passed onto the adjacent field, while at 2 sites at least part was held in scrubland or dug-over ground. However, in one of these 2 some water reached the nearby stream.

In late winter 1990 turbid run-off from the bulb field at 535344 (near Rosevidney and treated with aldrin in 1988) passed westward down a lane for about 100 m. There it entered a second daffodil field and was joined by more turbid water flooding the lower part of the field. From there the combined discharge passed southwards across the floodplain meadows for about 300 m before entering the brook above Gitchell Bridge.

The data in Table 6 confirms the potential for enhancement of pesticide residue levels in colluvium, once the soil has been disturbed by slurrying or erosio previously noted in the Newlyn and Hayle catchments. The effects here are usually less marked (mean aldrin enhancement 1.605 against 14.6 in the Hayle catchment and 1.256 against 4.2 for dieldrin). Since solubility of aldrin and dieldrin is very low and the compounds' affinity for soil particles very high, it is useful to compare enhancement of their residues against suspended solids content, and via that with source levels in the field soils. (Because of the higher water solubility of simazine and carbendazim such comparisons cannot be made). In run-off (Table 6) enhancement of the residues is stronger than in the soil (mean concentration factor of aldrin plus dieldrin in run-off being 7.597 compared with 1.317 in colluvium). This suggests that the soil material retained in suspension or in colloidal form (principally some organic matter fractions and clay-size material) are particularly important as the sites of pesticide residues. It may also indicate that under some circumstances these fractions are particularly prone to removal into suspension from the soil by rain impact or the ensuing run-off. The samples taken from the 4 pools (9th January 1991) (Table 6) about 16 hours after a run-off event indicate that the pesticide bearing materials have an extended suspension time in still water.

Table 6 Aldrin and dieldrin residues in soil and in solids suspended in run-off

Site and Grid Reference	Aldrin	Dieldrin	Aldrin + Dieldrin
	mg/kg of suspended solids		
Polgoon, beans (7 years) 462305			
Field soil	0.123	0.932	1.055
Colluvium	0.135	1.049	1.184
Concentration factor	**1.098**	**1.126**	**1.122**
Run-off	0.083	0.899	0.982
Concentration factor	**0.675**	**0.965**	**0.931**
Pool	0.205	0.599	0.804
Concentration factor	**1.667**	**0.643**	**0.762**
Polgoon, potatoes (4 years) 461304			
Field soil	0.048	0.316	0.364
Colluvium	0.098	0.632	0.730
Concentration factor	**2.042**	**2.000**	**2.005**
Run-off	0.073	0.986	1.059
Concentration factor	**1.521**	**3.120**	**2.909**
Pool	0.125	1.393	1.518
Concentration factor	**2.604**	**4.408**	**4.170**

Continued.....

Table 6 Continued

Site and Grid Reference	Aldrin	Dieldrin	Aldrin + Dieldrin
	mg/kg of suspended solids		
Ludgvan Leaze (5 years)			
510327			
Field soil	0.003	0.082	0.085
Colluvium	0.013	0.125	0.138
Concentration factor	**4.333**	**1.524**	**1.624**
Run-off	0	0.433	0.433
Concentration factor	**0**	**5.280**	**5.094**
Tregurtha (8 years)			
530317			
Field soil	0.007	0.149	0.156
Colluvium	0.003	0.066	0.069
Concentration factor	**0.429**	**0.443**	**0.442**
Run-off	0.076	1.106	1.182
Concentration factor	**10.857**	**7.423**	**7.577**
Pool	0	0.403	0.403
Concentration factor	**0**	**2.705**	**2.583**
Townfield (Varfell) (3 years)			
504320			
Field soil	0	0.074	0.074
Colluvium	0.026	0.188	0.214
Concentration factor	**-**	**2.541**	**2.892**
Run-off	0.526	1.106	1.182
Concentration factor	**-**	**22.054**	**29.162**
Pool	0.197	0.683	0.880
Concentration factor	**-**	**9.297**	**11.892**
Tregadjack (7 years)			
493329			
Field soil	0.009	0.122	0.131
Colluvium	0.009	0.136	0.145
Concentration factor	**1.000**	**1.115**	**1.107**
Run-off	0	0.300	0.300
Concentration factor	**0**	**2.459**	**2.290**

Continued.....

Table 6 Continued

Site and Grid Reference		Aldrin	Dieldrin	Aldrin + Dieldrin
		mg/kg of suspended solids		
Treassowe (5 years)				
500333				
Field soil		0.003	0.072	0.075
Colluvium	(	0.005	0.059	0.064
	(	0.002	0.035	0.037
Concentration factor	(	**1.667**	**0.819**	**0.853**
	(	**0.667**	**0.486**	**0.493**
Run-off		0	0.391	0.391
Concentration factor		**0**	**5.431**	**5.213**
Giants Grave W (Varfell)				
506321				
Field soil		-	-	-
Colluvium		0.011	0.206	0.217
Run-off		0.010	0.074	0.084
Pool		0.051	0.898	0.949

Concentration factor = $\frac{\text{content in colluvium or run-off}}{\text{content in field soil}}$

Figures in years indicate time since aldrin applied

Mean concentration factors:

Aldrin in colluvium	1.605
Aldrin in solids suspended in run-off	3.465
Dieldrin in colluvium	1.256
Dieldrin in solids suspended in run-off	5.799
Aldrin + dieldrin in colluvium	1.317
Aldrin + dieldrin in solids suspended in run-off	6.598

The past custom of dipping the roots of broccoli plants in a suspension of aldrin was noted above and in the studies around Newlyn and Hayle (Harrod 1989, 1991). 5 fields, each known to have carried several crops treated in this way, but without other aldrin applications to the land, were identified (Table 7). The practice aimed to reduce rootfly attack and probably persisted for about 25 years prior to 1989. In 4 of the 5 fields amounts were below or near to analytical detection limits. In the 5th, some dieldrin residue was evident.

Table 7 **Aldrin and dieldrin residues in fields planted with broccoli dipped in aldrin suspensions**

Location	Grid reference	Aldrin	Dieldrin
		µg/kg	
Marazion	534303	< 1	1
Marazion	526311	< 1	3
Gulval	484318	< 1	3
Gulval	486317	< 1	3
Marazion	512308	< 10	48

MOVEMENT OF OTHER PESTICIDES

Soil samples were taken from daffodil fields where erosion or slurrying have caused soil movement, for analyses for carbendazim and simazine. This aimed to establish whether movement comparable to that affecting aldrin and dieldrin could be identified as affecting other pesticide residues. The analytical results are in Table 8.

Both pesticides are applied by boom sprayers, for carbendazim (or benomyl) the foliage of the daffodils being the target, with simazine it is weeds or the soil surface before the crop emerges in mid-winter. Inevitably a proportion of both reach the soil. Sampling of field centre topsoil was by scraping to remove the upper 5 mm of soil from daffodil ridges, flanks and furrows with 5 subsites replicated at 10 m intervals along the contour. Colluvial samples were taken from the full depth of fresh material.

Simazine was applied in January to Tollhouse, Roadside and Townfields (but not at Rosevidney). Carbendazim was sprayed to the daffodils at Playing Field in January, at Playing Field, Tollhouse and Rosevidney in February, at Tregilliowe and Roadside in March and at Tollhouse, Tregilliowe, Rosevidney and Roadside in April.

Although some sites show larger amounts in the colluvium than in the field soil, others show the reverse. The variability in the results makes conclusions difficult. Variability may be explained by the difficulty of sampling soil for surface applied pesticides and by the uncertain nature of the processes of translocation of soil particles and attached residues.

Table 8 Carbendazim and simazine residues in the soil and in solids suspended in run-off

Site and grid reference		Carbendazim (mg/kg of suspended solids)	Simazime
Tregilliowe (Daffodils) (pool)			
532323			
Field soil	(15/3)	(0.880	-
	(30/4)	(1.398	-
Colluvium	(15/3)	(1.100	-
	(30/4)	(1.915	-
Concentration factor		(**1.250**	-
		(**1.370**	-
Run-off	(15/3)	0.925	-
Townfield[2] (Asparagus)			
504320			
Field soil	(20/2)	-	0.260
Colluvium	(20/2)	-	1.240
Concentration factor		-	**4.769**
Tollhouse[2] (Daffodils)			
508233			
Field soil	(20/2)	(0.060	0.165
	(30/4)	(0.080	0.580
Colluvium	(20/2)	(0.143	0.062
	(30/4)	(0.070	19.410
Concentration factor		(**2.383**	**0.376**
		(**0.875**	**33.466**
Run-off	(22/2)	8.108	0.084
Playing field[1]			
512329			
Field soil	(20/2)	(0.950	-
	(30/4)	(2.259	-
Colluvium	(20/2)	(1.150	-
	(30/4)	(0.894	-
Concentration factor		(**1.211**	-
		(**0.396**	-
Rosevidney			
532339			
Field soil	(15/3)	0.190	0.010
Colluvium	(15/3)	0.170	0.020
Concentration factor		**0.895**	**2.000**
Run-off	(15/3)	38.462	0.00096
Roadside[1]			
513328			
Field soil	(15/3)	0.420	0.150
Colluvium	(15/3)	0.110	0.040
Concentration factor		**0.262**	**0.267**

[1] = Crowlas [2] = Varfell

PESTICIDE RESIDUES IN STREAM WATER

To supplement sampling of run-off from the land a series of stream samples were taken, with results presented in Table 9. Sampling was carried out under similar (warm frontal) weather conditions to those chosen for sampling run-off from land, on 18th March and 4th and 6th April. Rainfall amounts before the samplings on 18th March, 4th April and 6th April are indicated in Table 9 and were only sufficient to encourage minor increases in stream flow, although turbid run-off from intensively used land was apparent. Low flow measurements were made prior to the rainfall on 6th April and during a dry spell on 11th April.

Three separate catchments were sampled, that of the River Larrigan below Polgoon Bridge; the Red River near its outfall at Marazion and a northern tributary at Gitchell Bridge; the Botreva Stream at Long Rock Bridge, a short distance above Long Rock Marsh, and a tributary at Ludgvan Dump.

The catchments above each site have land treated with aldrin. Land use is mixed, with substantial areas of field vegetables and with daffodils still grown in each catchment. Above Polgoon Bridge aldrin-treated land is at Castle Horneck, Rosehill, Tremethick Cross and Polgoon. Daffodils are still grown at Castle Horneck and the drainage from the Polgoon sites enters the River Larrigan in 2 outfalls, about 40 and 200 m above the sample point. The Botreva basin has had aldrin applied at Varfell, Botreva, Tregadjack and Treassowe, with daffodils currently grown at Varfell, where simazine and carbendazim are applied as described above. Drainage from several of the run-off sites enters the Botreva Stream, either via the channel at Ludgvan Dump or by the road drainage system along the Longrock by-pass, about 200 m north of Long Rock Bridge. Aldrin-treated land at Collorian, Gorran, Whitecross, Canonstown, Rosevidney and Archlane is above the Gitchell Bridge site. Currently there are several daffodil fields in this basin. The site at 513311 (Red River Bridge) is below several areas of treated land, including the Gitchell catchment and land at Crowlas, Treassowe, Tregilliowe and Tregurtha.

During the modest increases in flow on 18th March, 4th and 6th April suspended solids amounts rose from the low (less than 10 mg/l) baseflow levels and were accompanied by the introduction of pesticide residues at all sites except Red River Bridge. Amounts and patterns of pollution are such that the figures are not easily interpreted, other than to demonstrate that even with only modest rainfall during the field capacity period, pollution by dieldrin, carbendazim and simazine takes place.

Table 9 **Pesticide residues in water courses**

Date	**18/3**	**4/4**	**6/4**	**6/4**	**11/4**
"Time"	**End of rain**	**End of rain**	**Before rain**	**End of rain**	**Dry spell**
Rainfall (at Drift)	2.5 mm/hr for 7 hrs	2 mm/hr for 2½ hrs	3.5 mm/hr for 2 hrs		-
Flow (m^3/s at Gitchell Bridge)	Slight spate 0.15	Low 0.05	0.02	Slight rise 0.06	Low 0.017
Gitchell Bridge 528340					
Dieldrin	75	<5	-	13	<5
Carbendazim	0	<0.1	<0.1	<0.1	<0.1
Suspended solids	330	25	5	152	6
Red River Bridge 513311					
Dieldrin		<5	-	<5	-
Carbendazim		<0.1	<0.1	<0.1	-
Suspended solids		12	2	11	-
Polgoon Bridge 461302					
Dieldrin		25	<5	<5	<5
Carbendazim		<0.1	<0.1	0.1	<0.1
Suspended solids		92	6	78	7
Long Rock Bridge 503315					
Dieldrin		<5	<5	16	<5
Simazine		<0.1	<0.1	0.1	0.1
Suspended solids		34	5	288	6
Ludgvan Dump 505320					
Dieldrin		50	18	47	<5
Simazine		<0.1	<0.1	0.5	0.1
Suspended solids		1680	8	1750	6

N.B. Dieldrin amounts are ng/litre, carbendazim μg/litre and suspended solids mg/litre, dried to 105°C.

Protection Against Future Pollution

The findings of this study largely support those of the work in the Hayle catchment (Harrod 1991, pp45-66). There recommendations (to which the reader is referred) for appropriate cropping, cultivation, soil management and land use strategies were put forward. They are summarised below. These are appropriate since the long persistence of aldrin/dieldrin residues and their preferential movement by run-off and erosion mean that a pollution risk will remain for a number of years.

In the preceding surveys it was demonstrated that enhancement of pesticide residues occurred in soil transported and redeposited as colluvium and pool deposits. This process is confirmed for aldrin and dieldrin residues. It is also shown that similar enhancement takes place in run-off when quantities of pesticide, relative to suspended solids contents, are compared with field soil content.

It is also shown that such run-off can be generated by very modest falls of rain (around 2 mm per hour over only short durations) during the field capacity period (usually October to April), once the right combination of soil and land use conditions (particularly triggered by winter use of the land) are obtained. In several observed instances (Table 4) this run-off amounted to over one third of the rainfall at around 2 mm per hour, carrying appreciable quantities of suspended solids and pesticide residues. Run-off under more intense rainfall was not monitored but it can be assumed that quantities of soil and pesticide residues lost from the land then would be somewhat larger.

SUMMARY OF RECOMMENDATIONS

1. Remedial action to prevent pollution will be needed for some years into the future.

2. Land use (that is cropping, cultivation and soil management practices) should seek to avoid run-off of water from the land and from riparian and strongly sloping fields in particular.

3. Some, particularly riparian, fields lack hedgebanks on their lower edges. Effective barriers to run-off should be constructed as soon as possible and the field restored to permanent grass.

4. Long term control of pollution is best attained by putting the land in high risk sites down to pasture. Conversion of arable fields to grassland is not without hazard, freshly established swards having similar erosion hazards to arable crops.

5. On arable land cultivations, in particular final ones, should follow the contour. Wheelings and other ridges and microfeatures should be avoided across the contour as these can readily channel water. Very fine tilths should be avoided.

6 Once pasture is well established in high risk sites management must continue to avoid run-off. Any stocking in late autumn, winter or early spring should be minimal.

7 Fallowing of land for a season after bulb crops should be avoided. Some green cover crop should be established quickly to protect the soil.

8 What levels of pesticide residues are acceptable after degradation require a decision between land use and environmental interests.

9 If satisfactory soil protection measures cannot be arranged with farmers more formal arrangements may be necessary, particularly where water abstraction or fisheries may be affected.

10 Crops grown in ridged ground, bulbs, potatoes and brassicas, on treated land, require appropriate management to reduce and eliminate run-off and transportation of soil material downslope. There are a few options:

a) Any new ridges should follow the contour, not the slope.

b) There should be protection from run-off from land upslope by the closing of upslope hedge banks using barriers of earth, or as short term measures, straw or geotextile.

c) Where configuration of the ground is likely to cause water to gather in the furrows and present a hazard of erosion, effective earth stops must be drawn across the furrows at reasonable intervals, say about 10 m, to minimise flow.

d) Where stop/tie ridges are employed some will require careful grading to allow tractors to pass along the furrows.

e) After harvest, working of the land should bear erosion hazards in mind. On slopes the ground should be left rough, cultivations should be along the contour, in particular the final passes.

11 On bulb fields over-winter erosion has been shown to be controlled by a cover crop of late summer-sown spring barley, broadcast and chain harrowed into the soil. Provided the cover is able to establish early, soil protection is good. The technique should be adopted.

12 Tine cultivation of the furrows of bulb fields in the summer will improve soil conditions and infiltration.

13 Tractor traffic along bulb field headlands can cause pollution. Wherever possible, such tractor traffic should be avoided, particularly on riparian fields. Sowing of grass on the headlands and use of low ground pressure vehicles may be beneficial and deserve evaluation. If unacceptable slurrying occurs then flowers should be removed from the field in a manner which avoids it, by hand if necessary.

14 Attention to shortcomings in land drainage near aldrin-treated fields will help to lessen pollution. The object must be to prevent surface flow across the field.

15 Where run-off and erosion have resulted in deposition of soil at the lower end of a treated field, this soil should be excavated and redistributed over the field. This will mean that the bund-like nature of hedgebanks along the lower ends of susceptible fields is restored.

16 Blocking of gateways or other breaches in contour-aligned hedgebanks, either permanently with earth, or temporarily with barriers of straw bales or geotextiles etc should be carried out, particularly until treated fields are re-established in pasture.

17 It will be prudent to monitor breakdown of dieldrin in local soils until amounts have declined to an acceptable level.

18 In the widespread freely drained soils, movement of soil water plays its part in sustaining stream flow. It requires sampling to determine what, if any, pesticide leaching is taking place. Samples should be taken from a number of sites representative of the soils, land use and pesticide applications. The purpose is to monitor residues in soil water in the topsoils and deeper subsoils both at times of flux and under stable, moist circumstances.

19 A programme monitoring water from land drains leaving treated land should be undertaken, with sampling during or after heavy rain and at low flows both during the field capacity period and during summer. As well as determining concentrations of pesticide residues, drain flow should be measured to indicate volumes.

20 Although reversion to grass will curtail run-off, occasionally surface flow may cross treated fields. This should be monitored for volume and concentrations of residues on riparian land and any used for arable crops.

21 In view of localised concentrations of residues in the colluvium in lower parts of some treated fields a systematic check of similar sites of all fields treated with aldrin should be carried out.

22 The NRA programme of stream monitoring should be upgraded. Sampling points should be above and below groups of known treated fields and visited during and after storms rather than at fixed intervals.

23 Systematic sampling of fine and organic stream sediments should be carried out.

25 Monitoring of the implementation and effectiveness of the recommended land management practices should be undertaken.

26 Research should be encouraged to clarify the disproportionately large residues of pesticides noted after soil movement, along with their siting and bonding within the soil and on suspended solids in run-off.

27 The criteria for pesticide registration should require full consideration of the likely range of agricultural, horticultural and other practices, and environmental (water, soil, slope, climatic etc) contexts which will accompany the product's application.

28 In view of the large number of aldrin treated fields in this and adjacent catchments and the persistence of residues, it is recommended that effective monitoring of pollution risk be carried out until acceptable degradation has occurred. This will be most readily possible with a risk modelling system, as described above, operated on a Geographic Information System such as SPANS. This should be coupled with twice yearly identification (preferably by aerial photograph interpretation) of high risk arable or horticultural use of treated fields.

TABLE 10 Soils analysed in the Mount's Bay Study

National Grid Reference	Location	Date	Aldrin µg/kg	Dieldrin µg/kg	Carbendazim µg/kg	Simazine µg/kg	Comment
508233	Tollhouse Field	30/04/91	-	-	60	165	Field soil
508233	Tollhouse Field	30/04/91	-	-	143	62	Interrow colluvium
484318	Gulval	30/04/91	< 1	3	-	-	Dipped broccoli
486317	Gulval	30/04/91	< 1	3	-	-	Dipped broccoli
512329	Playing Field	30/04/91	-	-	2259	-	Field soil
512329	Playing Field	30/04/91	-	-	894	-	Varved colluvium
510327	Ludgvan Leaze	30/04/91	3	82	-	-	Field soil, cabbages
510327	Ludgvan Leaze	30/04/91	13	125	-	-	Colluvium
530317	Tregurtha	30/04/91	7	149	-	-	Field soil
530317	Tregurtha	30/04/91	3	66	-	-	Colluvial slick (as water here 09/01/91)
534303	Marazion	30/04/91	< 1	1	-	-	Dipped broccoli
526311	Marazion	30/04/91	< 1	1	-	-	Many broccoli dips
500333	Treassowe	11/04/91	3	72	-	-	Field soil
500333	Treassowe	11/04/91	2	35	-	-	Sandy colluvium + rolled aggregates

Continued.....

TABLE 10 continued

National Grid Reference	Location	Date	Aldrin µg/kg	Dieldrin µg/kg	Carbendazim µg/kg	Simazine µg/kg	Comment
500333	Treassowe	11/04/91	5	59	-	-	Silty colluvium
532323	Tregilliowe	30/04/91	-	-	1398	-	Field soil (site of waters 20 & 22)
532323	Tregilliowe	30/04/91	-	-	1915	-	Interrow colluvium
46103054	Polgoon	11/04/91	48	316	-	-	Field soil potatoes
46143050	Polgoon	11/04/91	20	115	-	-	Sandy colluvium
46143050	Polgoon	11/04/91	98	632	-	-	Silty colluvium
46303169	Higher Trannack	11/04/91	4	99	-	-	Ley field soil
46323168	Higher Trannack	11/04/91	1	24	-	-	Ley sandy colluvium
49343297	Tregadjack	11/04/91	9	122	-	-	Field soil
49363296	Tregadjack	11/04/91	2	31	-	-	Sandy colluvium
49373297	Tregadjack	11/04/91	9	136	-	-	Fine colluvium in track
504321	Town Field	20/02/91	< 10	74	-	260	Field soil. Asparagus
504320	Town Field	20/02/91	26	188	-	1240	Colluvium (see water here 09/01/91)
506321	G. Grave W	20/02/91	11	206	-	-	Site of pool (see water here 09/01/91)
508233	Tollhouse Field	20/02/91	-	-	80	580	Field soil

Continued.....

TABLE 10 continued

National Grid Reference	Location	Date	Aldrin µg/kg	Dieldrin µg/kg	Carbendazim µg/kg	Simazine µg/kg	Comment
508233	Tollhouse Field	20/02/91	-	-	70	19410	Colluvium in furrow. Analyses checked via B Brown, NRA
512329	Playing Field	20/02/91	-	-	950	-	Field soil
512329	Playing Field	20/02/91	-	-	1150	-	Colluvium lower end
573320	Tregembo	20/02/91	<10	130	-	-	Repeat (now year 17) (See Harrod 1991 Appendix and page 27)
462305	Polgoon A	20/02/91	123	932	-	-	Field soil
462305	Polgoon A	20/02/91	135	1049	-	-	Fine colluvium (see water here 09/01/91)
512308	Collins, Marazion	08/03/91	<10	48	-	-	Dipped broccoli
531333	Tregilliowe	15/03/91	-	-	880	-	Ridge/field soil
531333	Tregilliowe	15/03/91	-	-	1110	-	Colluvium in furrow = water 20
532339	Rosevidney	15/03/91	-	-	190	10	Ridge/field soil
532339	Rosevidney	15/03/91	-	-	170	20	Colluvium in furrow ends
513328	Roadside Field	15/03/91	-	-	420	150	Daffodil ridges
513328	Roadside Field	15/03/91	-	-	110	40	Fine colluvium on lower headland

TABLE 11 Water analyses carried out in the Mount's Bay study

National Grid Reference	Location	Date/Time	Aldrin ng/l	Dieldrin ng/l	Carbendazim µg/l	Simazine ng/l	Suspended Solids mg/l	Flow l/hr	Rain	Comment
461302	R Lariggan	22/2, 11.30	<5	22	<0.1	-	36		))	Run-off leaving Polgoon
462305	Polgoon	22/2, 11.50	213	2320	-	-	2580	4320 from 0.36 ha	)))	Water entering ditch from beans
506321	Giant's Grave W	22/2, 13.25	80	594	-	-	8000	13,015 from several ha	)22/02/91)rain)10.15	"Gusher" entering road
508325	Long Lane Field	22/2, 14.00	-	-	0.5	14	4	14,062 from 2 ha	)to)16.00	Flow from headland
508325	Long Lane Field	22/2, 14.00	-	-	-	-	148		)hrs at)2.3	SS from furrows
508233	Tollhouse Field	22/2, 14.30	-	-	3	31	370	17,316 from 1.2 ha	)mm/hr)	All from furrows
508233	Tollhouse Field	22/2, 14.30	-	-	-	-	530		))	SS from pool
506320	Varfell	22/2, 15.00	-	-	-	-	1380	2,995 from 1 ha	)))	Broccoli run-off
512329	Playing Field	22/2, 16.00	-	-	9	-	770	2,808 from 1.28 ha	))	Daffodils run-off
505320	Ludgvan Dump	22/2, 16.30	58	199	-	*	380		Easing	Asparagus run-off
504320	Town Field	22/2, 16.30	123	382	-	*	234	15,120 from 2 ha		
504318	Botreva Stream	22/2, 16.35	<5	6	-	*	81			
504315	Long Rock Bridge	22/2, 17.00	8	53	-	*	128	.		
528340	Gitchell Bridge	22/2, 17.30	-	-	-	-	59			Pesticide sample bottle broken

TABLE 11 continued

National Grid Reference	Location	Date/Time	Aldrin ng/l	Dieldrin ng/l	Carbendazim µg/l	Simazine ng/l	Suspended Solids mg/l	Flow l/hr	Rain	Comment
489327	Gulval	22/2, 12.30	-	-	-	-	4400			Maize run-off.
462305	Polgoon beans	9/1, 13.50	164	479	-	-	800		Dry	Pool, day after rain
461304	Polgoon fallow	9/1, 13.55	35	390	-	-	280		Dry	Pool in fallow (later potatoes)
504320	Town Field	9/1, -	116	403	-	-	590		Dry	Pool in asparagus bed (Also see sample of 22/02/91) (Also see soil sample)
506321	G.Grave W	9/1, -	21	368	-	-	410		Dry	Pool from complex catchment (See also sample here 22/02/91). (Also see soil sample here)
530317	Tregurtha	9/1, -	<5	133	-	-	330		Dry	Pool below cereals (see also sample of 18/03/91)
643343	Crowan (stream cottage)	23/11/90	9	380	-	-	770			Run-off through garden
463315	Trannack	15/3, 9.00	<5	37	-	-	58	4,644 from 0.9 ha	)15/3/91)rain)4.45 to	Run-off from grass - video
461304	Polgoon	15/3, 8.30	121	1627	-	-	1650	2,160 from 0.44 ha	)10.00 hrs)at 1.4)mm/hr	Run-off from potatoes (see also here 09/01/90)) - video
493329	Tregadjack	15/3, 9.35	<5	210	-	-	700	11,280 from 1.4 ha	)))	Run-off from potatoes - video
500333	Treassowe	15/3, 10.00	<5	45	-	-	115	3,621 from 0.75 ha	))	Run-off from cereals

TABLE 11 continued

National Grid Reference	Location	Date/Time	Aldrin ng/l	Dieldrin ng/l	Carbendazim µg/l	Simazine ng/l	Suspended Solids mg/l	Flow l/hr	Rain	Comment
503322	Varfell	15/3, 10.30	142	256	-	-	1400		))	Run-off from broccoli - video
510327	Ludgvan Leaze	15/3, 10.45	<5	225	-	-	520	4,320 from 3.9 ha max	))	Cabbage run-off
528340	Gitchell Bridge	15/3, 11.00	<5	5	4	<0.1	38		Rain stopped	
513328	Roadside Field	15/3, 11.30	-	-	5	9	136			Run-off from Daffodils
532339	Rosevidney	15/3, 13.30	-	-	4	0.1	104			Pools in daffodil furrows
531333	Tregilliowe	15/3, 14.00	-	-	407	-	440			Pools in daffodil furrows
530317	Tregurtha	18/3, 11.10	5	73	-	-	66	768 from 0.75 ha	)18/3/91)rain 6.00-)13.15 hrs	Run-off from cereals (see also sample of 09/01/91)
528340	Gitchell Bridge	18/3, 14.45	<5	75	0.2	<0.1	330		)at 2.5 mm/hr	
528340	Gitchell Bridge	4/4, 6.05	<5	<5	<0.1	-	25		))	
503315	Long Rock Bridge	4/4, 6.20	<5	<5	-	<0.1	34		)2 mm/hr)for 3.75	
505320	Ludgvan Dump	4/4, 6.30	<5	50	-	<0.1	1680		)hrs)	
513311	Red River Bridge	7/4, 6.40	<5	<5	<0.1	-	12		))	
461302	Polgoon Bridge	4/4, 6.55	<5	25	<0.1	-	92		)	
461302	Polgoon Bridge	6/4, 7.15	<5	<5	<0.1	-	6		) 3.5 mm/hr) for 2 hrs	
461302	Polgoon Bridge	6/4, 14.10	<5	<5	0.1	-	78		)	

TABLE 11 continued

National Grid Reference	Location	Date/Time	Aldrin ng/l	Dieldrin ng/l	Carbendazim µg/l	Simazine ng/l	Suspended Solids mg/l	Flow l/hr	Rain	Comment
461302	Polgoon Bridge	11/4, 11.30	<5	<5	<0.1	-	7		Dry	
505320	Ludgvan Dump	6/4, 7.45	<5	18	-	<0.1	8		)3.5 mm/hr)for 2 hrs	
505320	Ludgvan Dump	6/4, 14.30	<5	47	-	0.5	1720		)	
505320	Ludgvan Dump	11/4, 10.35	<5	8	-	<0.1	3		Dry	
503315	Long Rock Bridge	6/4, 8.00	<5	<5	-	<0.1	5		)3.5 mm/hr)for 2 hrs	
503315	Long Rock Bridge	6/4, 14.35	<5	16	-	0.1	288		)	
503315	Long Rock Bridge	11/4, 10.30	<5	<5	-	0.1	6		Dry	
528340	Gitchell Bridge	6/4, 8.15	-	-	<0.1	-	5		)3.5 mm/hr)for 2 hrs)	Organochlorine sample lost, Wessex Water lab.
528340	Gitchell Bridge	6/4, 14.48	<5	13	0.1	-	152		)	
528340	Gitchell Bridge	11/4, 10.05	<5	<5	<0.1	-	6		Dry	
513311	Red River Bridge	6/4, 8.30	-	-	<0.1	-	2		)3.5 mm/hr)for 2 hrs)	Organochlorine sample lost, Wessex Water lab.
513311	Red River Bridge	6/4, 15.20	<5	<5	<0.1	-	11		)	

* Wessex lab. - no result due to quality control failure

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