FULL MAPS ETC...

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Report of the Investigation into the Presence and Influence of Lead in the Silvermines area of County Tipperary

Foreword

The Inter-Agency Group is pleased to present to the Minister for Agriculture, Food and Rural Development its Report of the Investigation into the Presence and Influence of Lead in the Silvermines area of County Tipperary.

The Report is the product of almost twelve months work by the Group and the agencies which participated in it. I would like to thank my colleagues on the Group for their sustained effort, commitment and co-operation over the almost twelve month period of the investigation. I would like to acknowledge also the contributions of the many others in each of the participating agencies whose particular knowledge, skills and competencies were essential to the conduct of the investigation.

On behalf of the Group, I would like to particularly thank the people of the Silvermines area, without whose consistent goodwill and co-operation an investigation of this type would not have been possible.

Finally in presenting its Report to the Minister and discharging its remit, the Group believes that implementation of the Recommendations contained herein will address the issues of concern which it has identified.

Aidan Murray
Chairman, Inter-Agency Group
Department of Agriculture, Food & Rural Development
June 2000

Executive Summary

INTRODUCTION

In early 1999, three cattle died from lead poisoning on a farm adjacent to the Gortmore Tailings Management Facility (TMF) in Silvermines, Co. Tipperary. Concern was expressed by people living in the area, and their public representatives, as to whether this had any wider significance for human or animal health in the area. Local concern was compounded by experiences in the 1980s which centred on dust-blows from the TMF and by a report published by the EPA in January 1999[1]. That report pointed out inherent risks of the TMF to animal and human health and the environment. It stated that "*the TMF represents a perpetual risk to human health and the environment. Thus it requires structured, comprehensive, active, and continued management*".

These circumstances led to the activation of a protocol for collaboration between public agencies dealing with issues such as human and animal health and the environment. An Inter-Agency Group (IAG), chaired by the Department of Agriculture, Food & Rural Development, was established and given the task of overseeing an investigation. Its particular remit was to conduct an investigation into the presence and influence of lead in the Silvermines area and to present its report to the Minister for Agriculture, Food, and Rural Development. The agencies which participated in the IAG were:

- Department of Agriculture, Food & Rural Development (DAFRD)
- Mid-Western Health Board (MWHB)
- Environmental Protection Agency (EPA)
- Teagasc
- Tipperary (North Riding) County Council (TNRCC)
- Department of Marine & Natural Resources (DMNR)

The responsibilities of individual agencies are detailed in Chapter 1 of the report.

The IAG first met on 22 June, 1999 and regularly thereafter. In all, the IAG as a whole met on 19 occasions, with the participating agencies meeting on many other occasions in relation to particular aspects of the investigation. Responsibility for work on particular components of the investigation was assigned, by the IAG, to the relevant agency or agencies. The people of the locality were informed how the investigation was structured and would progress. Local media were periodically advised of its progress.

THE AREA

The Silvermines area has a long history of mining spanning over a thousand years. The IAG determined that in order to provide an insight into the influence on the lives of local people of the presence of lead in the locality it was necessary that the investigation cover a geographic area which encompassed the main lead-related features of the locality. The geographic scope of the investigation was thus defined as an area of approximately 23 square kilometres, which included the TMF at Gortmore, other mine workings, some 90 farms, and Silvermines village itself (*see* Map 1).

LEAD IN HUMANS

Lead is a naturally occurring element and is ubiquitous in the environment. It is toxic to humans. Whilst historically, lead toxicity was mainly seen as an occupational hazard, the experience of the latter part of the 20th century has shown that lead is a major environmental hazard for children. Most of the work on lead as an environmental hazard has focused on the urban environment where leaded petrol and paint have been the primary sources. The influence of lead in a rural mining environment is less clear, but it seems reasonable to draw some analogies with the urban experience. Ongoing research over the past 50 years has resulted in a lowering of the 'safe' concentrations of lead in humans, particularly children. It is now considered appropriate to investigate and ameliorate blood lead concentrations above 20 µg/dl in children and to advise precautionary measures if concentrations are above 10 µg/dl. Accordingly, the IAG accepted this lower concentration of 10 µg/dl as the safety threshold for the concentration of lead in human blood.

INTERNATIONAL GUIDELINES FOR LEAD IN SOIL

As a naturally occurring element, lead is present in soils. There are currently no standardised guideline values for lead which are applicable across Europe. However, many European countries have developed guideline values which apply in their own countries. In 1998, the US EPA issued guidelines for lead in dust, soil and paint. While derived from urban situations, where the lead originated from paint or industry, they give recommendations for management of contaminated soils and establish standards for hazardous concentrations of lead in paint, dust, and soil.

Studies suggest that mining waste may be different from other sources of lead in contributing to blood lead concentrations. Specific guidelines for management of contaminated rural soils do not exist, but research in urban situations has shown that where lead is found in concentrations greater than those described in the US EPA guidelines, the management of lead-contaminated soil can result in the reduction of blood lead concentrations in children. In the absence of directly applicable reference concentrations, the IAG felt it appropriate to have particular regard to the US EPA guidelines.

HUMAN HEALTH

The human health component of the study concentrated on ascertaining concentrations of lead in humans living in the defined area. Blood-sampling was directed particularly on children. Screening found that lead concentrations in the population were within acceptable international concentrations and below those found in urban areas in the developed world, although 1% of individuals had borderline or slightly raised results. These individuals were advised on appropriate interventions needed to minimise further lead exposure. On the basis of the results of the programme of blood testing, the IAG found that the high lead concentrations in the local environment are not, at present, being transferred to the human population. There is however the potential for such transfer, particularly to children.

The IAG considers that there is a need for appropriate monitoring, particularly insofar as children in the area are concerned.

ANIMAL HEALTH

Lead poisoning is the most commonly-reported form of toxicity in cattle in this country. The majority of outbreaks can be traced to the ingestion of man-made products such as lead batteries and lead-based paints. Lead poisoning outbreaks arising from environmental sources (i.e. geochemical), on the other hand, are less common and are generally associated with lead mining or smelting activities. Previous outbreaks of lead poisoning in animals in the Silvermines area were reported in the late '60s (horses) and early '80s (cattle). In addition to the outbreak which occurred in cattle on a farm in early 1999, and which gave rise to the present investigation, the IAG also collected information on a probable multi-case outbreak which occurred on another farm in 1998. A further multi-case outbreak was confirmed on this latter farm in April, 2000. While it was not possible to definitively determine the source of lead in these cases, it was most probably environmental in origin, i.e. river sediment, tailings, soil or dust. Both of the farms concerned had access to areas of elevated environmental lead concentrations.

Other than these cases, the investigations of the IAG showed no evidence of widespread clinical lead toxicity in animals in the area. A small number of cattle were found to have high concentrations of lead in their blood and tissue. In most cases, these animals were from farms on or near areas with elevated environmental lead concentrations.

The IAG concluded that the risk of sporadic outbreaks of lead poisoning will persist on the small number of farms with access to the highest concentration of environmental lead. The application of appropriate management techniques - combined with enhanced awareness and information for farmers - will reduce this risk.

DRINKING WATER AND FOOD

The results of tests undertaken as part of the investigation indicated that drinking water for human consumption within the area is generally compliant with the Drinking Water Regulations for lead and cadmium (European Council Directive 80/778/EEC of 15 July, 1980[2]; given effect in Irish law by SI No.81 of 1988[3]). Lead concentrations were satisfactory in all except three of the 77 samples of locally-grown fruit and vegetables samples analysed. Further sampling will be necessary during the course of 2000. In the meantime, it is advisable that all fruit and vegetables grown locally be washed before consumption.

Tests on milk and meat (muscle) produced locally did not indicate cause for concern. A small number of liver and kidney samples contained concentrations of lead in excess of the permitted maximum. The IAG concluded that appropriate ongoing monitoring and control measures at meat plants should be continued.

ENVIRONMENTAL MONITORING

Rivers and streams

Water samples taken from the Kilmastulla river and Yellow river and their tributaries identified areas, particularly in the Yellow river catchment, where lead concentrations in the water are elevated. The Kilmastulla river showed fair to variable water quality with some moderate pollution, primarily due to excessive siltation and organic pollutants such as animal slurries. The stream from the Garryard mine complex showed bad water quality and serious pollution indicating a toxic effect[*]. This was caused by the very high concentrations of heavy metals in the sediments. The high lead concentrations recorded in the stream leaving the Garryard complex and a stream from the Silvermines mountains contribute to the lead load in the Yellow river. Lead concentrations in the Yellow river exceed the standards specified in the Drinking Water Regulations and water from this source should not be used for human consumption. Water is safe for animal consumption provided sediments are not disturbed.

Sediment in rivers and streams

Sediment samples taken from the Kilmastulla river and Yellow river and their tributaries tend to mirror the results obtained for surface water, with the Yellow river catchment showing the highest values. Sediments associated with mining activities, which contain heavy or toxic metals, represent a threat to human and animal health and the environment. Such sediments can be disturbed and redistributed naturally during flooding or by activities such as dredging or allowing animals direct access to water for drinking. The IAG concluded that rivers and streams in the Yellow river catchment should not be used for recreational purposes, e.g. swimming. Animals should not be allowed direct access for drinking.

Mining-related sites

Samples taken from the Gortmore TMF, Shallee tailings, Garryard mine complex, and the Silvermines school play area, showed very high concentrations of lead. Such high concentrations of lead require that humans and animals should be protected from the influence of lead at these sites. The IAG concluded that these areas should be fenced immediately to control human and animal access. In the case of the school play area, immediate re-surfacing is required.

Dust monitoring

The dust deposition monitoring undertaken in the vicinity of the TMF at Gortmore indicated that the majority of readings obtained were well below the German T.A. Luft limit. During the monitoring period, this limit was exceeded on a number of occasions. The elevated concentrations all occurred in gauges located close to the base of the TMF indicating that distance from the TMF has influenced the metal content in the deposited dust. There is no evidence to date that wind direction influences dust deposition rates. The dust monitoring programme will continue until the risk of dust blows is eliminated.

Soil, Herbage, Fodder and Water (for animals)

Approximately one third of the soils in the area had lead values that exceeded 1,000 mg/kg, a value that was considered by the IAG to represent a reasonable cautionary concentration for agriculture. Elevated concentrations of other metals, especially zinc and cadmium, accompanied this. Many soils were acid and had low phosphorus availability. Both of these factors would be expected to increase the impact of lead on plants and animals. Soils in the Silvermines school play area were exceptionally enriched in metals, especially lead.

Herbage and silage lead concentrations, although elevated, were lower than the concentrations which would be expected to present a serious risk to animal health. Lead concentrations in drinking water for animals were considered safe.

The magnitude of the soil lead concentrations encountered must be considered as having a potential to impact on crop growth and quality and on animal health and quality. Exceptional combinations of circumstances may increase the risks. Adoption of improved fertiliser and management practices could serve to reduce any potential negative impacts.

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[*] A toxic effect is where certain animal species are totally absent which would normally be present even in cases of organic pollution.

MANAGEMENT OF MINING-RELATED SITES

The IAG considers that the present condition and management of the former mine workings, most notably the TMF at Gortmore, the Shallee tailings, the Garryard mine complex, and the area above Silvermines village, is not acceptable from the point of view of protecting human and animal health in the Silvermines locality. Measures must be taken without further delay at these and other sites in the area to manage the risk to health which they pose. Such measures will require a purposeful and sustained commitment by all concerned over the short, medium and longer terms.

It is the view of the IAG that it is essential that the necessary action under this heading be taken according to a clear timetable of the shortest possible duration. Technical assessments need to be undertaken to define the necessary risk management measures. Issues of land and mineral ownership will also need to be clarified. It is equally important in the view of the IAG that the people of the area be provided with insight into such action and with an opportunity to make appropriate input.

OVERALL CONCLUSIONS

The detailed Conclusions and Recommendations of the IAG are set out in Chapter 9 of the report. There are 39 Recommendations.

As with other locations in the country, both rural and urban, there are risks arising from the particular characteristics of the area which must be managed to ensure the safety of local people. In the case of Silvermines, risks arise both from historic mining operations and from the naturally occurring lead and other metals on which such operations were based. The IAG believes that the Silvermines area is a safe place in which to grow up, live and work, provided that certain precautions are taken. These precautions can be taken by public agencies, other interests, and local people themselves.

The general reassurance which the IAG believes it can give the people of the area does not seek to minimise or ignore the fact that the legacy of past mining operations poses particular risks. In order to avoid exposure to these risks local people should refrain from certain activities, e.g. swimming in local rivers. It will be particularly necessary to exercise care in relation to the areas of the locality accessed by young children. Care must also be taken in relation to animals. For most people, these precautions should entail little disruption in their way of life. As noted above, it is necessary for residents of other areas of the country also to have regard to local risks in going about their daily lives.

For most local people, living safely in the Silvermines area will entail following advice given to them by the public health authorities. For those involved in farming and food production, it will entail following the advice of their veterinary practitioners, DAFRD and Teagasc. The investigation has shown that foodstuffs can be produced safely in the area. Planning and development should also take account of the environmental characteristics of the area.

The IAG concludes that the issues which initiated this investigation are a consequence of elevated lead concentrations in the local environment. These in turn reflect the natural geology of the area and the impact of more than a thousand years of mining. In formulating its recommendations, the IAG has adopted a precautionary approach. It has recommended a number of immediate actions which, once taken, will give protection pending the implementation of the remaining recommendations contained in the report.

In summary, the IAG considers that while there are risks arising from certain characteristics of the Silvermines area, these risks can be clearly identified and managed. Once the necessary strategies to manage the identified risks have been drawn up, the actual process of risk management in the area falls to be undertaken by national and local public agencies, by the local community, by individuals and by others, including Mogul of Ireland Ltd. Effective management of risk into the long term will require the positive and committed co-operation of all concerned.

OVERALL RECOMMENDATIONS

Human Health

1. The school play area in Silvermines village should be resurfaced immediately. It should then be fenced in to define a safe play area.
2. Children should be discouraged from accessing other areas of high lead content.
3. A programme of annual blood lead surveillance should be implemented for pre-school and school children in the Silvermines area. The results of this programme, which will commence in Autumn, 2000, should be reviewed after 2-3 years of testing.

4. Internal and external environmental sampling should be carried out in Silvermines village on a once-off basis in Autumn, 2000 for the purpose of providing additional insight into the presence and influence of lead in this particular location and thereby a more informed basis for future precautionary measures relating to human health within this population centre.

5. Steps must be taken to enhance and maintain public awareness of the presence and influence of lead across the Silvermines area.

6. The active involvement and assistance of the local community, and community-based organisations, should be secured in addressing lead exposure and specific prevention strategies through education on:

    - basic hand-washing practices with a special focus on pregnant women and the parents of young families;
    - preparation of locally grown fruit and vegetables for domestic consumption;
    - the importance of adequate dietary intake of calcium, iron and vitamin C;
    - dust minimisation in the home.

Animal Health

7. Further evaluation will be required on some farms with elevated blood or tissue lead concentrations in order to identify environmental and other factors contributing to lead intake. A management system designed to minimise lead intake by food animals should be drawn up by DAFRD and Teagasc for these farms

8. Details of a generally applicable regime of grazing and other farm management controls (including access to streams, etc.), designed to minimise lead intake by animals, should be made available by Teagasc to all farmers in the area.

9. In the case of calves, which have a higher susceptibility to lead poisoning, particular attention should be paid to the implementation of farm management controls given in this report.

10. A targeted programme of blood-sampling and analysis should continue in the area in order to more fully assess the impact of environmental lead on animal health. This will be subject to ongoing review.

11. In order to assist in the accurate identification of cases, herdowners in the area and their veterinary practitioners should make available to the RVL of DAFRD for laboratory examination, animals which are suspected of having died from lead poisoning.

12. As in the case of farm animals, care should also be taken to protect the health of domestic and companion animals.

Food Safety

13. Water used for human consumption should only be taken from supplies which comply with the standards laid down in the Drinking Water Regulations.

14. The following steps should be taken in the preparation for human consumption of all locally-grown fruit and vegetables in order to reduce dietary exposure to lead:

    - thoroughly wash all fruit and vegetables in running water of drinking quality;
    - peel potatoes prior to cooking;
    - remove the outer leaves of leafy vegetables prior to washing and consumption.

15. A further programme of fruit and vegetable sampling should be undertaken - the duration of which should be determined by reference to the results of testing as they become available.

16. Milk produced from any dairy herd in the area which was not in production during the 1999 round of milk sampling should be sampled and tested when production resumes.

17. Livers or kidneys with lead or cadmium concentrations above those permitted for human consumption should be excluded from the food chain.

18. Monitoring of lead concentrations in the livers and kidneys of all slaughtered animals from farms in the area - using the Cattle Movement Monitoring System (CMMS) for animal/herd identification or suitable alternative - should continue until end-2000 – at which stage the need for further monitoring will be reviewed.

19. Tissue monitoring may need to be re-introduced in the future in the event of incidents giving rise to excess lead concentrations in the area, e.g. significant dust-blows or flooding.

20. Cadmium concentrations should be monitored in tissues (kidney) of animals from farms on which high soil cadmium concentrations have been detected.

Soils, Herbage (grass), Fodder & Animal Drinking Water

21. Farmers in the area should have soils analysed to establish lime requirement and nutrient status and soils should be limed to pH 6.5 if necessary and phosphate applied as required. Nitrogen should be applied to maintain a dense and healthy grass sward.
22. Farmers should refer to soil lead maps to determine the lead status of their soils.
23. Soils, particularly on farms showing elevated soil lead concentrations, should be disturbed as little as possible. This entails avoiding poaching by animals and damage to sward by machinery.
24. Animals should not be allowed to ingest herbage which has been heavily contaminated by soil - either by poaching, flooding or wind-blow from tailings facilities.
25. Where re-seeding is required, part of the area should first be tested to ensure that re-growth occurs. Late flowering, preferably diploid ryegrass varieties which best ensure a dense sward, should be used.
26. Farmers should not spread sediment from drainage works on their pastures. Spoil from drainage and dredging works on the Yellow river and its tributaries should be fenced off and not spread over pastures. Pastures subject to flooding in the Yellow river catchment should not be grazed while obviously contaminated with sediments.
27. Animals should not be allowed direct access to water-courses. Drinking water for animals should be extracted from streams (e.g. by pump).

Rivers, Streams, Sediment & Dust Monitoring

28. A programme of works to rehabilitate and manage the Garryard mine complex and water discharges from the site should be drawn up and implemented.
29. Biological and physico-chemical monitoring should be continued on the Yellow and Kilmastulla rivers. In addition, further water sampling upstream of Silvermines village should be undertaken. Sampling in the area should be reviewed on an annual basis.
30. To avoid the disturbance of sediments, the rivers and streams in the Yellow river catchment area should not be used for recreational purposes.
31. In the short term, the current dust monitoring programme should be continued until the risk of dust blow has been eliminated.
32. The emergency plan to prevent dust-blows should be implemented in full.
33. A contingency plan should be prepared and available for implementation in the event of a major dust-blow incident.

Mining-Related Sites

34. The settlement pond and tailings lagoon at Garryard, the unvegetated tailings at Shallee, and the Gortmore TMF, should all be securely fenced off until definitive rehabilitation has taken place.
35. Mogul will manage the Gortmore TMF under the emergency plan agreed with TNRCC, pending final rehabilitation.
36. Management plans for each historic mine site in the area should be formulated by end-2000 by consultants employed by DMNR. Agreement on and implementation of management and rehabilitation plans should accord with clear timetables and should be completed within the shortest possible timeframes. If the necessary co-operation is not forthcoming from all concerned, the relevant agencies should have recourse to their statutory powers or to legal remedy.
37. Management plans should be formulated and implemented for other sites with elevated lead concentrations in the Silvermines area which may be identified.

Implementation of Recommendations

38. An implementation group should be established and mandated to ensure that the recommendations contained in this report are implemented. Its composition should include all of the relevant agencies. It should have regard to appropriate local views and needs, and to guidelines on the management of lead in the environment. It should

also maintain a dialogue with the people of the area in relation to their concerns and the progress of its work. It should meet at regular intervals with the local community.

39. As a matter of priority, an expert group - to include international experts - should be established to formulate guidelines applicable to Ireland on the management of lead in the environment. The conclusions of this group, which should be asked to complete its work within a short timeframe, should be available to, and should inform the work of, the implementation group in giving effect to the recommendations contained in this report.

REFERENCES

1. **EPA.** Report on investigation of recent developments at Silvermines Tailings Management Facility, Co. Tipperary. EPA, Wexford. 1999.

2. **European Council Directive** of 15 July 1980 relating to the quality of water intended for human consumption [80/778/EEC], Official Journal of the European Communities, No L229, pp 11-29, 30 August 1980.

3. **Statutory Instruments**: S.I. No 81 of 1988. European Communities (Quality of Water Intended for Human Consumption) Regulations, 1988. Pl.5598, Dublin: Stationery Office.

Chapter 1

Introduction

.1 ORIGINS OF THE INVESTIGATION

The investigation which has resulted in this report was prompted by the deaths in early 1999 of three cattle on a farm close to the Gortmore Tailings Management Facility (TMF) in Silvermines, Co. Tipperary. Post-mortem examination of these animals at the Department of Agriculture, Food and Rural Development's (DAFRD) Regional Veterinary Laboratory (RVL) in Limerick confirmed that they had died as a result of lead poisoning. Concern was subsequently expressed by people living in the Silvermines area, and by their public representatives, as to whether this outcome had any wider significance for human or animal health in the locality. Local concerns were compounded by experiences in the 1980s which centred on a dust-blow from the Gortmore TMF and a report published by the Environmental Protection Agency [1] (EPA) in January, 1999 entitled "*Report on investigation of recent developments at Silvermines Tailings Management Facility, Co. Tipperary*". This concluded that "*the TMF represents a perpetual risk to human health and the environment. Thus it requires structured, comprehensive, active and continued management*".

In these circumstances, it was decided to activate a protocol or set of arrangements for collaboration between various public agencies having responsibilities for human health, animal health and the environment in circumstances where such collaboration is necessary to adequately address a case which may be multidimensional in its cause or effects (Appendix 1.1). This protocol was formulated as a by-product of the Askeaton Animal Health Investigations. The activation of the protocol led to the establishment of the Inter-Agency Group (IAG), chaired by DAFRD, which has overseen the investigation. The other agencies which participated in the IAG were the Mid-Western Health Board (MWHB), Teagasc, the EPA, the Department of the Marine and Natural Resources (DMNR), and Tipperary (North Riding) County Council (TNRCC). The particular remit of the IAG was to conduct an investigation into the presence and influence of lead in the Silvermines area and to present its report to the Minister for Agriculture, Food and Rural Development.

.2 CONDUCT OF THE INVESTIGATION AND DETAILS OF PARTICIPATING AGENCIES.

The responsibilities of the agencies which participated in the IAG were as follows:

- The *Department of Agriculture, Food and Rural Development*, in addition to Chairing the IAG and co-ordinating the investigation, had responsibility for the animal health and certain public health aspects, encompassing post-mortem animal examinations and tissue analysis for lead. This involved taking and arranging the testing of blood samples from animals, testing milk samples which were taken on-farm, and testing tissues taken from animals sent from farms in the area to slaughter plants.
- The *Mid-Western Health Board* had responsibility for the human health aspects. This involved the collection and testing of blood from people living in the area - with particular emphasis on children under 12 years old. It also involved the collection and analysis of water and vegetable samples and the provision of relevant information and test results.
- The *Tipperary (NR) County Council* has been involved in ongoing contacts with the owners of the Gortmore and other mine workings aimed at securing satisfactory arrangements for ongoing management and maintenance. While this in a sense may have been seen as a separate exercise to the investigation it is one to which the investigation clearly had to have regard. In addition, the Council has been involved in dust monitoring in the Silvermines area and further supported the investigation by providing a range of information relevant to the locality.
- The *Environmental Protection Agency* had responsibility for sampling and analysis of surface water, stream sediments and tailings within the area of investigation. In addition, the EPA provided technical support and assistance to TNRCC in relation to dust monitoring and the risk assessment and rehabilitation works carried out by Mogul on the TMF.
- *Teagasc* had responsibility for an extensive programme of sampling and testing of soil, silage, hay, and water (for animal consumption) in the locality.
- The *Department of the Marine and Natural Resources* is responsible for mineral resources and for the regulation of mining activity throughout the State. It provided the investigation with historical mining information relevant to the Silvermines area and has made input on a variety of relevant regulatory aspects.

The work of the investigation began on 22 June, 1999. The first priority was to evaluate existing information and to identify what further information was required. It was discovered that very little information was available on human and animal health in the area in the 1990's which would be of use to an investigation into the 'presence and influence of lead'. As a result, much new information had to be collected. Sampling and testing began under a number of headings (e.g. blood testing of farm residents, blood testing of cattle, milk testing, etc.) and progressed to include substantial programmes of sampling and testing under all headings. This was augmented where necessary by other data-gathering exercises involving, for example, the use of questionnaires.

At the outset, the IAG recognised the need for the co-operation and goodwill of the people of the locality if it were to satisfactorily discharge its mandate by conducting and reporting on a meaningful investigation. This was readily forthcoming and was maintained throughout the investigation. The IAG recognised also the desirability of generally keeping the people of the area advised of the progress of the investigation. This was done by means of statements issued to local media after IAG meetings, by contact with local public representatives, by literature distributed in the area, by a Public Meeting held in Silvermines Community Hall on 1 September, 1999, and by the availability to local people of MWHB personnel who were based in the Community Hall at the early stages of the investigation. The IAG committed to meeting again with local people on publication of its report.

The IAG met on 17 occasions over the period of the investigation. In addition, there were many meetings between individual agencies, some of which involved parties outside of the IAG, for the purpose of addressing individual aspects or components of the investigation. This included contact with and reference to the work of international experts. Finally, extensive fieldwork (i.e. sampling, testing, visiting farms, etc.) was undertaken by the participating agencies and considerable laboratory resources were deployed in support of the investigation. While the investigation was initially focused on certain farms in the area, its scope was quickly extended to encompass the whole of the local community in the area.

The IAG decided at the outset that it would place particular emphasis on two factors in progressing its work. Firstly, in order to minimise anxieties in the local community, it recognised that persons should not have to wait until the investigation as a whole was completed before getting the results of tests with which they were most concerned. Accordingly, it was decided that the results of all tests would, in every instance, be given to the persons directly concerned when such results became available. Secondly, the investigation and report would respect the privacy and confidentiality of individuals in the area to the greatest extent possible, consistent with undertaking an exercise of this kind.

.3 AREA OF INVESTIGATION

One of the first tasks of the IAG was to identify the geographical boundary of the studies. The source of the lead that caused the deaths of the animals was a primary focus and it was decided that there were basically three broad possibilities.

1. Man-made sources of lead e.g. lead paint, lead batteries, etc.
2. Natural geological occurrence of lead in the area contributing lead to soils and stream sediments. Stream sediments can be applied to land through drainage works or during flood events.
3. Related mining activities e.g. tailings ponds, mine sites, settlement ponds etc.

All three sources of lead were considered during the investigation. The area of investigation was initially delineated by the need to include both the farms where animal deaths occurred and the mining activities adjacent to these farms. The extent of the natural occurrence of lead was subsequently quantified by examination of the results of a geochemical survey undertaken by Mogul of Ireland Ltd (Mogul) in 1963 as part of their mineral exploration works. The survey was carried out in a NNW-SSE orientation on a sample grid 240 m x 60 m. It is understood that soil samples were taken at approximately 300 mm to 400 mm depth. The analytical method used was called the 'Bloom Cold Extract Method' which measured freely available lead.

Map 1 illustrates the lead concentrations obtained from the Bloom analysis of soil samples (hand-contoured map of grid results). Examination of this historical mineral exploration data identified a lead-enriched area where soil lead concentrations were elevated above normal background concentrations i.e. greater than 25 mg/kg. It is interesting to note that elevated soil lead concentrations in the vicinity of Gortmore pre-dated the construction of the TMF in this area. The information obtained from this survey map was then used to redefine the area of the present investigation. Farms boundaries and DEDs were superimposed upon this map to delineate the extent of the investigation.

This area of approximately 23 square km embraces some 90 farms, including the farms where the animals died, the TMF at Gortmore, the tailings at Shallee, the lagoons and settlement pond at Garryard, the principal mine sites of the area and associated tailings facilities, and the Silvermines village. It is most likely, therefore, that the source of the lead that resulted in the initiation of this investigation, whether natural or man made, is to be found within this area. The IAG thus decided to concentrate its investigations within the area indicated in Map 2.

.4 OCCURRENCE OF LEAD IN THE SILVERMINES AREA

The Silvermines area lies along the northern flank of the Silvermines Mountain where Lower Carboniferous limestones are faulted against Devonian Old Red Sandstones and Silurian Shales. The geology is dominated by a complex series of structures known as the Silvermines Fault Zone. Associated with those structures are extensive mineralised deposits. For over 1,000 years, from the 9th century until 1993, mining of these deposits for zinc, lead, silver, copper and barite has been carried out intermittently. Evidence of this long mining history is visible along the hillside and includes the remains of shafts, flooded open pits, mine buildings, tailings facilities etc. over a distance of some 5 km stretching from Silvermines village to Shallee cross-roads (Map 3).

.4.1 Former mine workings and tailings facilities

At Shallee, a number of lead-bearing veins which were worked intermittently during the 19th and 20th centuries - until mining finally ceased in 1958 - can be grouped into two areas: Shallee East & Shallee West (Map 4). In the 19th century, at Shallee West, approximately 14 lead veins were worked from the surface. Excavations were up to 80 m long and 10 m deep. The veins were 1 – 2 m thick. Argentiferous galena (silver lead sulphide) formed bands within the veins approximately 200 mm thick and the remainder of the veins consisted of barite. Also at Shallee East, over 40 mineralised veins were worked. Approximately 20 of these veins were worked from the surface and the remainder from underground. The principal minerals here were, as at Shallee West, argentiferous galena with barite and quartz forming the remainder of the veins. During the 20th century, mining continued intermittently at Shallee East from 1949 until finally ceasing in 1958.

During the 19th century, open-cast copper mining operations were conducted at Gortshaneroe which were later obliterated by the more recent 20th century Magcobar barite workings. Major mine workings, principally for zinc, were also recorded at Ballygowan and Knockanroe to the south of Silvermines village. Traces of these phases of mining, including mine buildings and tailings facilities, can be seen along the hillside from Silvermines village to Shallee cross-roads.

At Ballygowan, there are extensive abandoned workings from the 19th and early 20th century in what is often referred to as the ‘calamine zone’. In 1950, a processing plant was built by the Silvermines Lead and Zinc Company at Ballygowan to treat the waste from these previous phases of mining. Zinc Oxide (calamine) production ceased here in 1951. The mineralised zone at Ballygowan is a 7.5 - 24 m thick gossan zone (leached and oxidised deposit near the surface). The zone contains zinc and lead as well as iron and manganese hydroxide. There is also evidence of a significant 19th century sulphur mine in the vicinity of the calamine works.

The Silvermines area is best known for the major zinc and lead deposits mined by Mogul from 1968-1982, and the barite deposit which was operated by Magcobar (Ireland) Ltd between 1963 and 1993. Two distinct but related zones of zinc-lead mineralisation were mined by Mogul. The deposits are spatially and genetically related to the major Silvermines Fault Zone. Production between 1968 and 1982 amounted to 10.7 million tonnes (Mt.) at 7.36% zinc and 2.7% lead. Additional unexploited deposits near the surface, as well as deeper resources of zinc and lead, are known from exploration in the area.

The barite deposit worked by Magcobar at Gortshaneroe is genetically related to the adjacent Mogul zinc lead deposits. Open-pit mining of this deposit began in 1962 and continued until the late 1980s. The open pit was approximately 300 m by 500 m in size and 70 m deep. This was followed by underground mining until 1993 when the mine closed. The underground workings were accessed from within the pit *via* a decline and extended for approximately 100 m. Mining from the Mogul mine extended to within approximately 30 m of the Magcobar workings. During its continuous 30-year operation the Magcobar barite mine produced 5.13 Mt. of ore.

.5 MINERAL OWNERSHIP

The position in relation to mineral title in the Silvermines area, as indeed elsewhere in Ireland, is highly complex. To have carried out mining in the area, a miner must have had either a State Mining Lease for all State owned minerals, or have secured a lease from any private owner(s) of minerals, or have acquired the minerals. Since the enactment of the Minerals Development Act, 1979, a State Mining Licence to mine privately-owned minerals is required unless the minerals are ‘excepted’ from that Act because they were being worked on 15 December 1978.

The ownership of minerals can be held separately from the lands in which they lie and there is no simple way of confirming ownership; it involves tracing ownership of land back until the minerals are found to be part of the title, then tracing forward all transfers of title until the minerals are separated from the land and then tracing subsequent transfers of each parcel of minerals. Transfers of separated minerals are rarely recorded in the Land Registry or in the Registry of Deeds.

The minerals in the Silvermines area comprise: State minerals to which the Minerals Development Act,1940 apply; private minerals which were worked out before the 1979 Act came into force; private minerals excepted from the 1979 Act; and, possibly, private minerals to which the 1979 Act applies. The distribution of the various categories of minerals is a patchwork.

.6 OBLIGATIONS UNDER THE MINERALS DEVELOPMENT ACTS, 1940-1999

Mogul carried out part of its operations under the State Mining Lease granted in 1965 and owned or privately leased the other minerals. The Shallee mine worked private minerals and was closed before the 1979 Act came into force. The Magcobar mine primarily worked private minerals. Its operations commenced before the 1979 Act came into force and so these minerals are regarded as excepted. It also worked some State minerals underground under a sub-lease from Mogul.

The State Mining Lease to Mogul ran from 1965 to December, 1998 - although mining ceased in 1982. The expiration of the lease triggered a general liability on the part of the lessee (Mogul) under Clause K to carry out such works as the Minister (now the Minister for the Marine and Natural Resources) may require for the purpose of leaving "*… all surface lands in a proper state so as not to constitute a danger to public health or to persons or animals traversing the same or in the vicinity thereof or to constitute a danger to neighbouring lands or crops therein*". This liability arises only in relation to the State minerals granted under the lease.

The Mogul mine extracted State minerals under the lease simultaneously with minerals it had acquired or leased from private owners. The lands from which these State and private minerals were mined form a patchwork pattern through the area which greatly complicates the issue of liability. It is further complicated by other former mining activities in the area, as well as changes in ownership and occupation of lands.

As Clause K allows only a once-off call on the lessee, and because of the complexity of the layout of state minerals under the lease, it is necessary to survey the whole of the area of Mogul's mining operation to ensure that all consequent holes, openings, subsidence, future risks of subsidence, and dangers to crops, animals and persons are identified, and for all the necessary works to be specified.

The Lessee was put on notice that it has a liability under Clause K (covering Gortmore and other locations) in December, 1999. The surveying and mapping of the area has been completed. In addition, the Geological Survey of Ireland has begun cataloguing all relevant records held in its Mining Record Archive; including those lodged with the Survey by Mogul when it closed the mine office. Based on the survey of the area, the Minister has made a call for tenders from suitably qualified consultants in the broad range of disciplines needed to advise on what management plans, remedial and rehabilitation works are necessary. This process is expected to be completed by mid-December, 2000. The Minister will then notify the lessee of the works it must undertake and agree the time-frame for completion of the works in order for it to fulfil its obligations under Clause K of the lease.

In addition to liability under Clause K of the Lease, Section 31 of the 1940 Act provides that the lessee under a State Mining Lease shall be liable to pay compensation for any damage to land or water supplies or for nuisance caused by the working of minerals under the lease. It would be a matter for any person who is entitled to compensation to establish that entitlement and pursue the claim.

.7 OBLIGATIONS UNDER OTHER ENACTMENTS

The Mogul mining operation at Silvermines did not require Planning Permission under the Local Government (Planning and Development) Act, 1963 as the process of constructing the mine was in train at the enactment date of 1st October 1966, and related works such as the Gortmore TMF were not "an unauthorised use" of lands within the meaning of that Act. Similarly, the Magcobar mine did not require Planning Permission. Operations at Shallee and Ballygowan had ceased prior to the enactment of the 1963 Act.

The current ownership of private minerals, and of the land in the area, needs to be established to identify who might have obligations or liabilities in respect of those minerals or lands under any other enactments or under Common Law.

.8 LIMITATIONS OF THE INVESTIGATION

The investigative work which led to this report covered a period of some nine months. It did not therefore span a full calendar year nor encompass all seasons of the year. This is not a particularly lengthy period for a scientifically-based investigation, particularly one of a multidimensional nature. While the IAG has confidence in the Conclusions and Recommendations contained in this report, the underlying monitoring, sampling and testing was undertaken over a period much shorter that would be common for investigations of this kind. The participating agencies would wish it to be understood that precise answers to all of the questions which might arise in this instance are possible only with detailed investigation over a much longer period, of perhaps some years. This was clearly not an option if the IAG was to hope to be in a position to respond to the demands of local people for answers on the main areas of concern within a short timeframe. In other words, there has necessarily been a ‘trade-off’ between concluding an investigation and reporting within a short timeframe (in a scientific context), and providing a mass of detailed and definitive scientific results, which could only be generated over a longer time-frame.

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Appendix 1.1

Inter-Agency Investigation Protocol

The protocol provides for a graduated approach to addressing any given case, with the number of participating agencies being expanded as various aspects of the case become apparent. Where the 'trigger' is an animal health problem, it is structured as follows:

(a) Notification of Problem

A problem which is not readily explainable or treatable is brought to the attention of the Regional Veterinary Laboratory (RVL) by the herdowner or his/her Private Veterinary Practitioner (PVP). The primary responsibility for alerting the RVL will rest with the herdowner or PVP. When significant animal health problems are identified, the Senior Research Officer (SRO) at the RVL will initiate a laboratory investigation and seek a full report from the PVP. The SRO will also inform the DAFRD's local Superintending Veterinary Inspector of the nature of the problem.

(b) Involvement of other Agencies

- If, on the basis of the report from the PVP, the SRO considers that the issue requires a wider investigation, e.g. into farm management practices, land fertility or any other aspect, he/she will consult the Teagasc Chief Agricultural Officer (CAO) for the area with a view to determining whether a joint DAFRD/Teagasc investigation (involving, as appropriate, the PVP) is warranted. If environmental factors are thought to be involved, the Local Authority and, where appropriate, the EPA will be invited to join in these consultations. In addition, the local Health Board or Regional Health Authority will be notified of the matter and may join the process if the Board / Authority considers it desirable that it do so.
- Alternatively, where the problem comes first to the notice of Teagasc, the CAO will initiate contact with the SRO in the appropriate RVL, as above.

(c) Undertaking of Investigations

- Where a joint DAFRD/Teagasc approach has been initiated, as above, it will encompass the full range of investigative procedures considered appropriate by each body. The SRO will at that stage be responsible for co-ordination.
- Where it has been decided that a joint DAFRD/Teagasc investigation is warranted, the Director of the Veterinary Laboratory Service and the Head of the Animal Health and Welfare Division of DAFRD will be so advised by the SRO and will be apprised of the nature of the problem.

(d) Further Actions

- When the actions detailed above fail to find a resolution, a report will be sent to the Animal Health and Welfare Division of DAFRD and to Teagasc, for consideration by a joint Ad Hoc Committee comprising the following:
    - DAFRD - Head of Animal Health & Welfare Division
    - Senior Superintending Research Officer (SSRO) from the DAFRD's Central Veterinary Research Laboratory (CVRL)
    - Senior Superintending Veterinary Inspector (SSVI) and Senior Agricultural Inspector (SAI) from DAFRD Head Office
    - Teagasc – Nominated Personnel

This Ad Hoc Committee will recommend appropriate further action.

If, following the investigations carried out at (c) above, the possible involvement of environmental factors is still not ruled out, the relevant local authority and the EPA will participate in the Ad Hoc Committee's deliberations. The local Health Board/Regional Health Authority will be notified of the convening of the Committee and may join it if the Board/Authority considers it desirable that it do so.

(a) Epidemiological Investigations

In cases where the reported animal health problems involve a number of farms in an area, the investigations to be undertaken as at (b) or to take account of the considerations at (d) above may include application of appropriate epidemiological sampling and monitoring techniques.

(b) Apportionment of Costs

The herdowner will be responsible for fees due to the PVP. DAFRD will waive laboratory fees for tests arising from investigation pursuant to (b) and (d) above, but will continue to charge laboratory fees that arise in the normal way. Teagasc will waive fees on hardship grounds.

(c) Co-ordination of Investigation

It is important that there is clearly defined responsibility for co-ordination in every instance of an investigation undertaken under the protocol. In cases where the ‘trigger’ is an animal health problem, initial co-ordination will be the responsibility of the SRO in the relevant RVL. Co-ordination of any further phases of investigation required following the deliberations of the Ad Hoc Committee will be decided by the Committee, having regard to the emphasis of those investigations. In the present case it was decided that the investigation should be co-ordinated by DAFRD. This led to the establishment of the Inter-Agency Group, chaired by DAFRD, which was to oversee the investigation.

(d) The Human Health Dimension

While animal health problems may in many instances be the ‘triggers’ for activating the protocol, the full importance of the human health dimension will be reflected in any investigation of a case which gives rise to human health concerns. There is no question of the human health dimension being seen as subsidiary to that of animal health, or indeed to other considerations. In cases where the ‘trigger’ is a human health problem, the responsibility for an initial enquiry and any follow-up study will be a matter in each case for the public health authorities. Procedures have been devised for addressing apparent clusters of human ailments and these procedures may also be implemented in cases where the public health agencies are drawn into an investigation ‘triggered’ by animal health issues but giving rise as it progresses to human health concerns.

(e) Environmental Investigations

Where the initial assessment of an animal and/or human health problem has concluded that a detailed, co-ordinated investigation is needed and that, additionally, there is a possibility that an environmental pollutant is involved, the following procedure will be implemented by the local authority and / or EPA, as appropriate, as part of that investigation:

- An assessment will be carried out of the pollutant emission potential of all local industry and other relevant activity.
- A risk analysis will be undertaken for any pollutant likely to be emitted to the local environment, in relation, in particular, to the animal or human health problem observed, including, where necessary, modelling of the dispersion of emissions.
- The available environmental monitoring data and any other relevant measurements for the affected area will be collated.
- Any measurements or additional monitoring deemed necessary to fill gaps in the database on local environmental quality will be undertaken.

(f) Other elements

The protocol also makes provision for the development over time of national databases on human and animal health issues and of national environmental monitoring programmes with appropriate local linkage.

Chapter 2

Lead in Humans – National and International Experience

.1 LEAD AND HEALTH

Lead is ubiquitous in the human environment. It is one of the metals present in the earth's surface, to which man is naturally exposed. It has proven useful to society since ancient times. Nevertheless, environmental contamination by lead has become a cause for concern. The main sources of lead in the environment in industrialised countries are leaded petrol, lead-based paints, mining, and smelting activities. Lead has no known physiological value. Toxicity can result from inhalation, ingestion and, less commonly, by skin exposure. Children are particularly susceptible to the toxic effects of lead because:

- the developing nervous system of the new-born has increased susceptibility to the toxic effects of lead;
- they have more hand to mouth activity than adults and are more likely to play in dirt;
- the efficiency of lead absorption from the gastro-intestinal tract is greater in children than in adults;
- nutritional deficiencies of iron or calcium which are prevalent in children may facilitate lead absorption.

For the general population, exposure to lead occurs from inhaled air or dust and the ingestion of food and water - with an approximately equal division between ingestion and inhalation. Adults absorb about 5 - 15% of ingested lead and retain less than 5%. Children absorb approximately 50% and retain about 30%.

Lead poisoning is usually asymptomatic, with the result that most cases go undiagnosed and untreated. Acute lead poisoning is relatively rare but occurs most commonly in young children with a history of pica (eating soil) or in adults in the occupational setting. For lead poisoning to develop, major acute exposures to lead need not occur. The body accumulates this metal over a lifetime and releases it slowly, so even small doses over time can precipitate lead poisoning. It is the total body burden of lead that is related to the risk of adverse effects. Once in the blood, lead is distributed primarily among the blood, the soft tissues (kidney, bone marrow, liver and brain) and mineralising tissue (bones and teeth). Mineralising tissue contains about 95% of the total body burden of lead in adults.

The most sensitive target of lead poisoning is the nervous system. Lead can also affect other systems in the body such as the production of blood, the kidneys, the reproductive system and the production of hormones.

.2 CHANGING PERCEPTION OF LEAD

Exposure to environmental lead has reduced in recent years. In Ireland in the late 1980's the excise duty on unleaded petrol was reduced to encourage its widespread use. New cars coming on the market over the past two decades have increasingly been designed to run on lead-free petrol. As a result of the European Union Auto-Oil programme, the marketing of leaded petrol has been discontinued in Ireland since January, 2000. This reduction in general exposure has been accompanied by a reduction in the acceptable concentration of lead in human blood, food, and water. The permissible concentration of lead in drinking water will also be significantly reduced over the next few years as a result of EU legislation.

.2.1 Acceptable lead concentrations in humans

Up to 1970, the upper limit of acceptable blood lead concentration in adults was 80 μg/dl[*]. This concentration was chosen because acute lead colic, or other adverse effects, were almost never encountered at lower lead concentrations. Up until 1965, the upper limit of acceptable blood lead concentration in children was 60 μg/dl. In 1970, 40 μg/dl was proposed by the Surgeon General of the United States as the acceptable blood lead concentration following studies which showed that the production of blood could be disturbed at concentrations above this. In the mid-1970s, the US Centers for Disease Control (CDC) recommended that this concentration be reduced to 30 μg/dl.

Recent data indicate significant adverse effects of lead exposure in children at blood concentrations previously believed to be safe. Some adverse health effects have been documented at blood lead concentrations at least as low as 10 μg/dl. The 1985 CDC intervention concentration of 25 μg/dl was revised downwards to 10 μg/dl in 1991.

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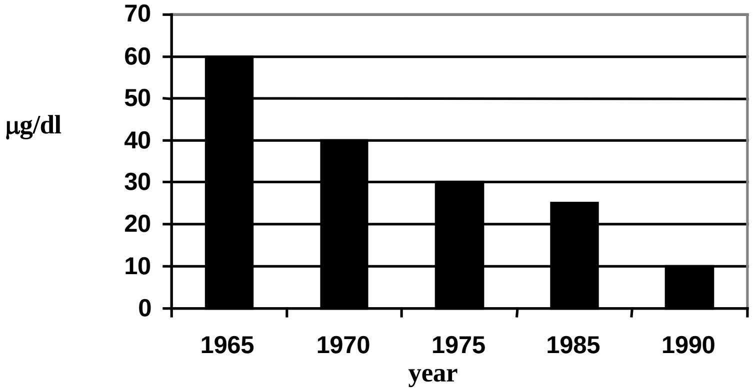
[*] Conversion: 10 μg/dl=0.483 μmol/l

Blood lead concentrations between 10 and 14 µg/dl are deemed to be borderline in the USA. Figure 2-1 shows the intervention concentrations for blood lead in children from 1965 to the present day.

Figure 2-1: Intervention concentrations for blood lead in children in µg/dl (US Centers for Disease Control and the Public Health Service)[1].



Little information is available on whether there are threshold concentrations for blood lead below which no toxic effects can be detected. Blood lead concentrations of 10 µg/dl may be associated with decreased intelligence and impaired neuro-behavioural development. Other documented effects at this concentration include decreased stature or growth, decreased hearing acuity and decreased ability to maintain a steady posture. Maternal and cord blood lead concentrations of 10-15 µg/dl appear to be associated with reduced gestational age and reduced weight at birth.

.2.2 Acceptable lead concentrations in drinking water

The drinking water standard for lead is 50 µg/l based upon the current Drinking Water Regulations (SI 81 of 1988). A new Drinking Water Directive (98/83/EC)[2] reduces that standard to 10 µg/l. Member States have until 25 December, 2000 to introduce the legal or administrative measures necessary to implement this Directive. The new standard for lead must be met, at the latest, 15 calendar years after the entry into force of this Directive.

.3 LEAD IN SOIL AND HUMAN HEALTH

Lead accumulates in the surface layers in soil because of its low solubility and resistance to microbial degradation. In the past two decades, attention in the USA has centred on soil and dust as important sources of lead exposure, especially for children. Soil and dust act as pathways to children for lead deposited from a number of sources. Since lead does not dissipate, biodegrade, or decay, the lead in dust or soil has the potential to become a long term source of lead exposure for children. Different relationships have been found between concentrations of lead in soil or dust and children's blood lead concentrations.

Currently there are no standardised guideline values for lead in soils which have been developed and can be applied across Europe. In 1995, the United Kingdom (UK) Department of the Environment published guidelines for contaminants in soils developed by an expert task force (Society for Environmental Geochemistry and Health; 1995)[3]. They defined guideline values as contaminant concentrations which, when exceeded in particular circumstances, would normally trigger either remedial action or more detailed risk assessment. Guideline values are given for differing soil pHs and for various scenarios. For example, different values are given for residential gardens, recreational allotments, parks, children's playgrounds and commercial or industrial land. The values reflect a precautionary approach and range from 530 to 8,500 parts per million (1 ppm = 1 mg/kg). These guideline values, however, represent geometric mean values that should not be exceeded and are not maximum acceptable concentrations.

Many other European and non-European countries have revised or are currently in the process of revising or drawing up policies and procedures to deal with contaminated land. These countries include the Netherlands, Switzerland, Norway, Belgium, Denmark, Germany, Canada, and Australia.

.3.1 US EPA national guidelines for lead hazards in soil

In August, 1994, the US EPA issued proposed guidelines for lead in dust, soil, and paint[4]. These guidelines were predominantly developed from urban situations where lead was more likely to be a result of contamination from leaded petrol, paint or industrial processes. The report recommends that bare residential soil be classified into two categories:

1. areas expected to be used by children,
2. areas where contact by children is less likely or infrequent.

More aggressive responses are recommended at lower lead concentrations where children are likely to come into contact with bare soil. The guidelines are summarised below:

> *Soil Lead Concentration Below 400 mg/kg:*
> US EPA guidelines identify 400 parts per million (1 ppm = 1 mg/kg) as the threshold above which some control (interim control or abatement) may be appropriate depending upon whether the area is expected to be used by children. As a general rule, concentrations below 400 mg/kg do not necessitate site-specific action.
>
> *Soil Lead Concentration Between 400 and 5,000 mg/kg:*
> At these concentrations, land use is the critical factor in determining what, if any, hazard control action is appropriate.
>
> - **If the area is expected to be used by children**, *interim controls* to prevent contact between children and contaminated soil are recommended by the US EPA for soil lead concentrations between 400 and 5,000 mg/kg.
> - **If contact by children is less likely or infrequent**, then interim controls should, in the view of the US EPA, be instituted when soil lead concentrations are between 2,000 mg/kg and 5,000 mg/kg and no site-specific action is recommended at concentrations below 2,000 mg/kg.
>
> *Soil Lead Concentration Above 5,000 mg/kg:*
> The guidelines recommend that abatement be undertaken when soil lead concentrations exceed 5,000 mg/kg, regardless of the potential contact by children. Abatement strategies can either removing or replacing contaminated soil or establishing permanent barriers (e.g. cement paving, permanent brick).

In 1998, a proposal was made (63 Federal Register 30302, June 3, 1998) to establish standards for hazardous concentrations of lead in paint, dust and soil under Section 403 of the Toxic Substances Control Act (TSCA)[5]. This proposal differs from the 1994 guidelines outlined above in some respects. The proposed soil-lead hazard concentration is 2,000 mg/kg and the soil-lead concentration of concern is 400 mg/kg with no reference being made to whether or not the area is expected to be used by children. Until the US EPA promulgates the final TSCA Section 403 standards, individuals are advised by that organisation to follow the 1994 guidelines.

.3.2 Lead from mining areas and human health

The results of studies at lead mining sites have indicated that soil lead contamination from mine tailings may be less likely to increase blood lead concentrations than lead derived from urban lead pollution or lead fallout from smelting plants. Postulated reasons for this include the following:

- mine wastes are typically of a larger particle size which decreases the bioavailability of lead in the gastrointestinal tract,
- the lead is normally in a form which is absorbed less in the gastrointestinal tract than other forms of lead,
- lead from mining sources generally contribute less to lead in the immediate environment of children than lead from other sources.

Some studies from mining areas have found either no strong correlation between soil lead and human blood lead or no elevated blood lead concentrations in areas with very high soil lead concentrations. These studies, when taken together, suggest that mining waste may be different from other sources of lead in contributing to blood leads[6]. A study of lead in a Derbyshire village in England concluded that past lead mining activities had caused the gross elevation of lead concentrations in garden soils and the contamination of house-dusts. However, while there was evidence that lead was ingested by children *via* the soil-dust-hand mouth pathway, blood lead concentrations were not raised. The conclusion was that the low solubility of the lead may have contributed to a low human bioavailability of soil-lead[7].

Lead is present in soils, water and air in a variety of different chemical and mineral forms, many of which are largely biologically inert. Many studies, both in the UK and in the USA, have shown that lead minerals can weather to nonavailable forms. The processes influencing these changes are likely to vary greatly under different climatic conditions[8]. Research is needed to identify the forms of lead in the environment, and their influence on pathways to human exposure.

Studies have shown that the abatement of lead-contaminated soil can be associated with a reduction in children's blood lead concentrations. The US EPA, in a review of 16 studies addressing lead abatement effectiveness, found that intervention did reduce exposed children's blood lead concentrations by 18 - 34% six to twelve months after intervention[9].

.4 BASELINE IRISH DATA REGARDING LEAD CONCENTRATIONS

An Irish study carried out in 1994 measured blood lead concentrations in new entrants to military service before and after basic military training[10]. Samples were taken from 46 army recruits. The group ranged in age from 17 to 27 with an average age of 21 years. The average baseline concentration in the group was 4.4 μg/dl with a range from 1.2 to 8.9 μg/dl.

In 1977, a pilot project for monitoring population exposure to lead was planned in Ireland as part of a European initiative. In Navan, which was close to a large lead and zinc ore body where mining was about to commence, blood samples were taken from a total of 283 children and 135 mothers. The average value for the children was 8 μg/dl and for the mothers was 7 μg/dl with medians of 7 μg/dl and 6 μg/dl respectively[11].

.5 INTERNATIONAL DATA REGARDING LEAD CONCENTRATIONS

.5.1 Survey of blood lead concentrations in the population in England (1995)

The Health Survey for England[12] is an annual nation-wide survey commissioned by the Department of Health, which began in 1991 and includes data about various aspects of the nation's health. In 1995, blood samples to estimate lead concentrations were taken from a sample of participants in that year's Health Survey.

A total of 6,857 samples were analysed from 6,517 adults (3,119 males and 3,398 females) and 340 children (180 males and 160 females). The distribution of blood lead concentrations was higher for males than females at all ages. The average value for males was 4.4 μg/dl and for females was 3.1 μg/dl. The average value for males living in rural areas was 4.2 μg/dl and for females living in rural areas was 3.1 μg/dl.

.5.2 Alspac study on lead in children (1994)

The aim of this study[13] was to determine blood lead concentrations at two years of age in a random sample of children born in the Avon area of England. Blood samples were obtained and analysed from 584 children. The average blood lead concentration was 4.2 μg/dl. 5.4% of the sample population had blood lead concentrations of greater than or equal to 10 μg/dl.

.5.3 National Health and Nutrition Examination Surveys

The second National Health and Nutrition Examination Survey[14] (NHANES II and III) described blood lead concentrations for the US population between 1976 and 1980. The findings of this study indicated that between 1978 and 1980, average blood lead decreased from 15.9 μg/dl to 9.6 μg/dl. This study also reported higher concentrations in children aged less than five years and in residents of urban areas.

The third National Health and Nutrition Examination Survey[15] described blood lead concentrations for the US population between 1988 and 1991. The findings of this study indicated that between these years the average blood lead was 2.8 μg/dl. The prevalence of blood lead concentrations greater than or equal to 10 μg/dl among children aged 1-5 decreased substantially from 88.2% during NHANES II to 8.9% during NHANES III.

.6 CONCLUSION

There has been a general reduction in human exposure to environmental lead in recent years. As data has emerged on the adverse effects of lead exposure at concentrations previously believed to be safe, acceptable blood lead concentrations in children and adults have been systematically reduced. The current acceptable blood lead concentration is 10 μg/dl. Studies carried out in Ireland, the UK, and the US, which calculated mean blood lead concentrations, have provided reference values for comparative purposes.

The relationship between soil lead and blood lead is complex. Whether lead in soil translates into lead in humans is dependant on the form and concentration of lead in the soil, its transfer to the direct environs of an individual, the behaviour of that individual, and the individual's physiological response to the lead presented to them. It is clear that in certain circumstances children and adults can have very high blood lead concentrations as a result of being exposed to lead in their immediate environs. Children and adults exposed to lead in industrial and urban situations have been found to have blood lead concentrations up to and exceeding toxic concentrations. These have been observed with soil lead concentrations of around 2,000 mg/kg or higher. Conversely, other children and adults exposed to similar soil lead concentrations have not been found to have such elevated blood concentrations.

The IAG has reviewed all this information and considers it precautionary and prudent to take the soil lead value of 2,000 mg/kg as the guideline for active management of the environment particularly if children are likely to be exposed. We believe this should be maintained until more definitive advice becomes available

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Chapter 3

Environmental monitoring

.1 INTRODUCTION

The Environmental Protection Agency (EPA) is responsible for the preparation of monitoring programmes on the quality of the environment e.g. water, air, etc. These programmes are implemented by Local Authorities, the EPA and other State agencies. The EPA undertook additional monitoring as part of the investigation. The monitoring undertaken included:

- Routine biological and physico-chemical monitoring of the Kilmastulla and Yellow river undertaken as part of the national water quality monitoring programme where over 13,000 km of river and streams are monitored on a three year cycle[1].
- Additional stream surface water samples were taken at nineteen locations along the Kilmastulla, Yellow River and its tributaries. Two further surface water samples were taken from the settlement pond and tailings lagoon located in Garryard mine complex.
- Stream sediment samples were taken at nineteen locations along the Kilmastulla, Yellow River and its tributaries.
- Dust gauges were located around the perimeter of the TMF at Gortmore to monitor dust deposition. A total of 16 gauges was installed where dust deposited was collected and analysed for metal content.
- Sampling and analysis of tailings, sludge and surface water from the following historical mine related sites:
  - Gortmore – tailings samples taken by Teagasc at TMF.
  - Shallee Cross-roads – tailings samples.
  - Garryard mine complex:

    - tailings/sludge samples from tailings lagoon north of railway line;
    - sediments from settlement pond at entrance of site;
    - surface water samples.

.2 RIVERS AND STREAMS

The Kilmastulla and Yellow rivers are monitored for water quality on a routine basis. The sampling locations on these rivers are listed in Appendix 3.1 and illustrated in Map 5. Both biological and physico-chemical monitoring are carried out on these rivers.

The biological monitoring measures the effects of any pollution on the plant and animal communities of the river and is undertaken in the summer-autumn period where river-flows are likely to be low and water temperatures highest. Surveys during this period demonstrate more accurately the impact of pollution on water courses. Biological monitoring of the Kilmastulla River commenced in 1971 (by An Foras Forbartha). Biological quality ratings are based on a scale which reflects the health and diversity of animals and plants living in the rivers. The scale runs from highest water quality rating of Q5 (good water quality and unpolluted) to Q1 (bad water quality and serious water pollution). The biological assessment mainly reflects the effects of biodegradable organic wastes (i.e. deoxygenation and eutrophication). However, it can also be used to show the effects of inorganic pollution e.g. heavy metal pollution. Where heavy metals such as lead, cadmium and zinc are present and impact on the invertebrates living in the streams and rivers, biologists refer to this as a '*toxic effect*' and use the prefix '0' to indicate the effect. A toxic effect is where certain animal species are totally absent which would normally be present even in cases of organic pollution. The biological river quality classification, together with a description of the effects of water pollution on the aquatic environment, are given in Appendix 3.2.

In general, physico-chemical monitoring identifies the pollutant e.g. lead, zinc, cadmium, or nutrients from agriculture and sewage, and is undertaken throughout the year.

.2.1 Biological monitoring results

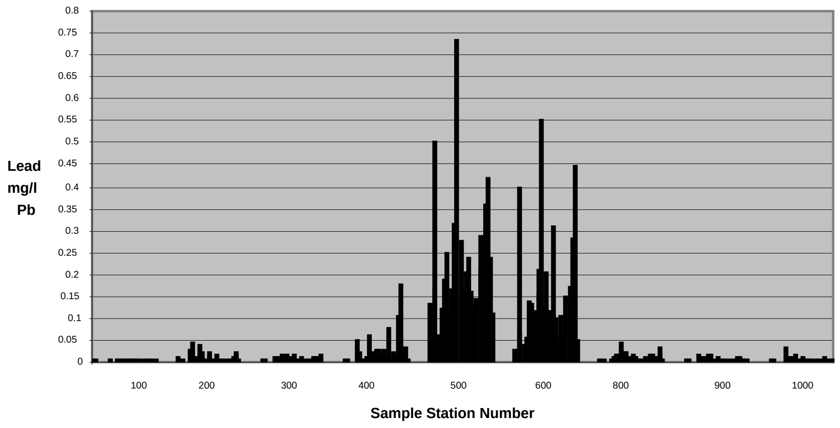
The Biological Quality Indices for the Kilmastulla and Yellow Rivers since 1971 are given in Appendix 3.3. The main findings include:

- The Kilmastulla river in the reaches above Silvermines village was rated Q4 at sampling station 0050 and Q3-4 at sampling location 0120 in the 1999 survey and remains in a satisfactory condition i.e. fair water quality and unpolluted. Downstream of its confluence with the Yellow river, the Kilmastulla river shows a rating of Q3 to Q4 with some moderate pollution recorded at Cranna bridge due primarily to excessive siltation and organic pollutants such as slurry. No toxic influences were recorded in the main channel of the Kilmastulla River in 1999. Toxic effects were recorded in the main channel in previous years, including 1993 and 1996.
- The Yellow river water quality is rated Q1/0 at sampling station 0400, Q3/0 at sampling location 0500 and Q3/0 at sampling station 0600. (Q1/0 indicates bad water quality and serious pollution and Q3/0 indicates doubtful water quality with evidence of toxic effect). All sampling locations show toxic effect. The cause of the toxic effect is most likely heavy metal pollution such as lead and zinc. This toxic effect has been recorded in the Yellow river from 1974. The stream leaving the Garryard mine complex has the poorest water quality rating at Q1/0. The biological assessments indicate a serious effect on fauna in the stream leaving the Garryard mine complex (Station 0400).
- There were moderate effects on the biology in the Yellow River at stations 0500 & 0600 (upstream and downstream of the confluence with the tributary from the Garryard mine complex respectively). The overall biological response recorded for the Yellow River in the latest investigation shows little change from that in 1987, with the same Q values recorded at the three locations.
- The biological monitoring has shown a toxic effect at all sampling stations on the Yellow river (stations 0400, 0500 and 0600) since 1971. These toxic effects are thought to be due to the presence of trace metals, especially zinc, cadmium, and lead.

.2.2 Physico-chemical monitoring results

A synopsis of lead results for the sampling period 1992 to 1998 is illustrated in Figure 3-1. This shows the results for individual samples taken from the Kilmastulla and Yellow rivers over the period 1992 to 1998 and demonstrates the variation in concentration of lead for that period. Results prior to 1992 are excluded because new laboratory instrumentation with greater sensitivity was introduced in 1992/93.

Figure 3-1: Lead concentrations in samples from the Kilmastulla and Yellow rivers for the sampling period 1992 to 1998.



The physico-chemical quality of the water in the Kilmastulla river and Yellow river shows elevated concentrations of lead and other metals such as cadmium and zinc when compared to standards specified in the Drinking Water Regulations. A summary of EU and National Water Quality Standards for lead, cadmium, zinc, and manganese is given in Appendix 3.4.

- Lead concentrations are highest at sampling station 0500 (i.e. Yellow River upstream of the confluence with the stream from Garryard mine complex). Elevated lead concentrations are also evident at sampling station 0400 i.e. stream leaving tailings lagoon at Garryard mine complex. The highest lead concentration recorded at sampling station 0500 was 0.735 mg/l which is 14 times the standard set in the Drinking Water Regulations for humans (80/778/EEC). Lead is a toxic cumulative poison.

- Cadmium and zinc concentrations are all high at sampling station 0400 (i.e. stream from tailings lagoon at Garryard mine complex). Cadmium is a toxic metal which is reflected in severe restrictions on its concentrations in drinking water for human consumption. Zinc is essential to humans and animals but can cause vomiting if ingested in high amounts. However, zinc is very toxic to the aquatic life and hence the stringent zinc standard for fishery water.
- Lead, cadmium, and zinc concentrations remain elevated at sampling station 0600 (downstream of the confluence of channels from stations 0400 and 0500).

.2.3 Additional surface water monitoring on Kilmastulla and Yellow rivers and tributaries

In addition to the routine monitoring of the Kilmastulla and Yellow Rivers, further surface water samples were taken on 15 and 16 September, 1999 at nineteen locations. These sampling locations were chosen to determine the sources and likely routes of lead movement in the Silvermines area. The samples were analysed for 27 individual metals, including toxic metals. The full results are given in Appendix 3.5.

The sampling locations (numbered SW2, SW4 to SW21) are shown on Map 6. Some of these samples correspond with the routine sampling locations (SW2, SW4, SW14, SW15 & SW16 correspond roughly with Routine Stations No. 0400, 0500, 0300, 0700 & 0600 respectively) and SW18 is located downstream of station 0600.

The results of the monitoring show that:

- The Kilmastulla river upstream of its confluence with the Yellow river has lead concentrations ranging from 2.3 μg/l (SW 10) to 45 μg/l (SW 12).
- The lead concentrations in the Kilmastulla river rise to 124 μg/l (SW 15) downstream of its confluence with the Yellow River. Further downstream the concentrations fall to 81 μg/l (SW21) probably due to dilution and reduced lead inputs.
- The lead concentrations in the Yellow River are elevated and range from 80 μg/l (SW 4) to 313 μg/l (SW 17). The results suggest that the Yellow River catchment is one of the main contributors of lead to surface waters in the Silvermines area. The origin of this lead is most probably the naturally occurring elevated soil lead concentrations in the catchment with contributions from the settlement pond and tailings dump located in the mine complex at Garryard and the hills above the Magcobar site at Gortshaneroe.
- Cadmium is high, (10.9 μg/l, i.e. twice the concentration permitted by the Drinking Water Regulations) at SW 2, the stream leaving the tailings lagoon from the mine complex at Garryard, a result also noted in the routine sampling (Station No. 0400). This correlates with the high cadmium concentrations in the sludge and water samples taken from the settlement pond and tailings lagoon within this complex.

.2.4 Conclusions on river and stream water quality

The stream leaving the tailings lagoon in the Garryard mine complex (0400) is seriously polluted (Q1/0) and contributes significantly to cadmium and zinc concentrations in the Yellow river. The Yellow river upstream of its confluence with the stream from the Garryard mine complex shows high lead concentrations contributing to the lead load in the Yellow river. The Yellow river is considered moderately polluted with toxic effect.

Lead and cadmium concentrations in the Yellow river and its tributaries exceed the concentration permitted by the Drinking Water Regulations and should not be used for human consumption.

Water in the Kilmastulla river shows fair to moderate water quality with no toxic effect.

.2.5 Recommendations

- A programme of works to rehabilitate and manage the Garryard mine complex and water discharges from the site should be drawn up and implemented.
- Biological and physico-chemical monitoring should be continued on the Yellow and Kilmastulla rivers. In addition, water sampling on the Silvermines river should be undertaken upstream of the Silvermines village. Sampling in the area should be reviewed on an annual basis.

.3 RIVER AND STREAM SEDIMENT SAMPLING

Suspended solids in river waters settle out on the river bed. This is a natural process known as sedimentation. Without modern safeguards and proper management, mineral extraction can result in increased suspended solids concentrations. Sediments associated with mining activities which contain heavy or toxic metals pose a threat to human health, animal health and the environment.

Rainfall and natural drainage of soils in areas with high soil metal levels can also wash out fine material and plant nutrients. The transport, deposition and remobilization of fine sediments in rivers, especially during periods of high flow, is a complex process that depends on the density and size of the particles and on the turbulence of the water. Sedimentation is often most evident in the wider or deeper areas of the river where the current is slack but even this is eventually stirred up and carried downstream by floodwaters. Sediments can be disturbed and redistributed naturally during flooding or by activities such as dredging or allowing animals direct access to streams for drinking.

.3.1 Investigation methodology

Map 7 shows the locations of the stream sediment samples which were taken from nineteen locations along the Kilmastulla and Yellow rivers. These were analysed for heavy metals and the full analysis is given in Appendix 3.6.

.3.2 River and stream sediment results

The stream sediment lead concentrations tend to mirror the results obtained for surface water with the Yellow river catchment showing the highest values.

The Yellow river sediment lead concentrations range from 1,780 mg/kg lead (SS 5/ 4634) to 12,332 mg/kg (SS 1/ 4630). The highest value recorded (12,332 mg/kg) was in a sample was taken from a small stream draining from the settlement pond located north of the railway line in the Garryard mine complex. Zinc concentrations (208,233 mg/kg) were also very high at this location.

The second highest value, 12,242 mg/kg lead (SS15/4663) was also recorded in the Yellow river just upstream of the Yellow bridge at Shallee cross-roads. High concentrations of lead were also found on streams draining north from the Silvermine mountains 5,853 mg/kg (SS 2 /4631) and 3,327 mg/kg (SS 4/ 4633). These demonstrate that the disused mining facilities in the area contribute to the lead and zinc in sediments.

The lead concentrations in sediments from the Kilmastulla river range from 627 mg/kg lead (SS 7) to 3,342 mg/kg lead (SS 9) prior to its confluence with the Yellow river. Downstream of its confluence, lead concentrations drop significantly i.e. 57 mg/kg for SS 13. However this concentration of lead recorded may be due to difficulties encountered obtaining a sediment sample from the deeper water here. Further downstream lead concentrations decline to 459 mg/kg at Cranna Bridge and 889 mg/kg at Kilnacranna Bridge.

.3.3 Conclusion on lead in river and stream sediments

It would appear from the sampling undertaken that the highest concentrations of lead in stream sediments occur in the Yellow river catchment. However, the concentrations recorded at SS4 (Yellow river), and SS6, SS8, SS9 and SS10 (Kilmastulla river) also indicate elevated lead concentrations in sediments. It is probable that elevated soil lead concentrations contribute to sediment lead concentrations. However, the converse could occur during flood events where stream sediments are deposited further downstream or on land adjacent to watercourses.
The disused mining facilities in the area are contributing sediments with high lead and zinc concentrations to the watercourses in the area.

.3.4 Recommendations

- To avoid the disturbance of sediments, the rivers and streams in the Yellow river catchment area should not be used for recreational purposes.

- Drinking water for animals should be extracted directly (e.g. pumped) from streams where elevated lead concentrations were recorded rather than allowing the animals access to the streams. This would reduce the risk of lead ingestion from sediments.

- Pastures subject to flooding in the Yellow river catchment should not be grazed while obviously contaminated with sediments.

- Spoil from drainage and dredging works on the Yellow river and its tributaries should be fenced off and not spread over fields.

- During site rehabilitation works of disused mining facilities, measures should be implemented to reduce sediment loading to rivers and streams e.g. silt traps, revegetation of bare areas such as tailings etc.

.4 MONITORING OF HISTORICAL MINE SITES

The EPA undertook sampling of the tailings at Shallee and at the Garryard mine complex on 15 and 16 September, 1999. Teagasc undertook sampling of the tailings at the TMF in Gortmore as part of their investigation. Map 8 shows the tailings sites and sample locations. The full heavy metal analysis from these sites is given in Appendix 3.7. A summary of the findings is given in Table 3-1.

Table 3-1: Heavy metal concentrations (mg/kg) in Gortmore, Garryard and Shallee tailings

Heavy metal		TMF[1] Gortmore	Garryard[2]	Shallee[3]
Lead	Range	2,609-15,540	14,085 – 51,230	3,240-3,843
	Mean	8,314	32,498	3,512
Zinc	Range	2,560-10,990	45,047 - 94,458	101 – 267
	Mean	6,747	75,509	197
Cadmium	Range	1.48-46.48	169 – 327	0.4 – 1.6
	Mean	19.65	266.0	1.2
Arsenic	Range	110-1,060	331 – 1,292	83 – 251
	Mean	427	676	158

[1] Eight samples taken from exploratory and extensive sampling by Teagasc, [2] six samples, [3] three samples.

Additional sampling of the tailings was undertaken in October, 1999 as part of a geo-environmental assessment into the proposed National Mining Heritage Centre at Shallee. The lead concentrations ranged from 537 mg/kg to 15,000 mg/kg with a mean value of 5,098 mg/kg[2].

Analysis of the surface waters taken from the settlement pond and tailings lagoon at the Garryard complex show elevated concentrations of lead, cadmium and zinc. Full analysis of the surface water is given in Appendix 3.8 and summarised in Table 3-2.

Table 3-2: Heavy metal concentrations of surface water samples from settlement pond at Garryard.

Heavy metal	Field and Lab No.		
	SW1	SW2[1]	SW3
Lead	372.8	193.6	118
Cadmium	11.3	10.1	4.4
Arsenic	12.0	6.2	1.5
Zinc	2,717	2,505	1286

[1] Stream leaving tailings lagoon flowing into Yellow River.

.4.1 Conclusions

- Samples from the Garryard mine complex, the TMF at Gortmore and Shallee showed very high concentrations of lead. Such high concentrations of lead means that humans and animals should be protected from the influence of lead at these sites.
- Sludges from the settlement pond and tailings lagoon located in the Garryard mine complex have the highest concentration of lead, zinc, cadmium, and arsenic. The water and sediments in the stream emanating from the complex reflects these high concentrations and contributes significantly to the serious water pollution in the Yellow River. The site contains a small settlement pond at the entrance and a tailings lagoon North of the railway line which covers an area of approximately 4 to 5 hectares, some of which is submerged. Substantial areas of tailings are exposed with little or no vegetation cover.
- The TMF at Gortmore has a high lead content and there appears to be considerable variation in lead concentrations across the surface of the facility.
- The Shallee tailings has the lowest concentration of lead in comparison to Garryard and Gortmore. However, the stream sediment sample taken downstream of these tailings had the second highest lead concentration i.e. 12,242 mg/kg (SS 15/4663).

.4.2 Recommendations

- The settlement pond and tailings lagoon at the Garryard mine complex, the TMF at Gortmore and the unvegetated tailings at Shallee, should be securely fenced off to prevent access until definitive rehabilitation has taken place.
- A programme of works to rehabilitate and manage the historical mine sites in the area should be drawn up and implemented.

.5 DUST DEPOSITION MONITORING

.5.1 Introduction

Particles of dust can be transported from exposed (non-vegetated) areas of the tailings pond and be deposited on the surrounding vegetation. This is most likely to happen following periods of dry weather and under the action of moderate to strong winds. Evidence that these dust movements can take place is found in various reports on dust blows during the period 1984 to 1987. The most severe dust blow occurred in February, 1985 (Mogul, 2000). Dust monitoring was carried out following these dust blows at Gortmore in 1986-1987. The studies in 1986-87 employed directional gauges that measured the flux of dust moving through a vertical plane in a particular direction.

A dust deposition monitoring programme was commenced in March, 1999 in response to local concerns regarding the potential for dust blows from the TMF at Gortmore. When the IAG was established in June, 1999, this programme was extended. The gauges employed in the present study measured the concentration of dust deposited through a horizontal plane and settling on the base of the sampling jar. Therefore, a direct comparison cannot be made between the recent dust measurements and measurements taken in 1986-1987.

There are no EU Air Quality Standards, existing or in pending Directives, for dust-fall and its metal content. However, in 1989, the Department of the Environment recommended that Local Authorities adopt as a source of reference the German T.A. Luft Regulations as well as other international standards. The T.A. Luft Regulations, 1986, set "*limit deposition concentrations*" (ambient air quality guideline values) for lead, cadmium and thallium in deposited dust.

In Ireland, statutory Air Quality Standards exist only for those pollutants for which exposure can occur by inhalation, (i.e. suspended particulates, lead, sulphur dioxide, oxides of nitrogen and ozone). The measurement of suspended particulate, and its metal content, cannot be achieved with simple deposition gauges. Dust monitoring results at this stage would indicate that this type of investigation is not required.

.5.2 Investigation Objectives

The primary objective of the dust deposition study was to quantify and assess the concentration of dust deposition from the TMF at Gortmore. The monitoring results obtained were then compared to the German T.A. Luft limits for metals in deposited dust. A summary of the T.A. Luft Limits is given in Table 3-3.

Table 3-3: T.A. Luft limits (μg/m^2/d) for lead, cadmium and thallium in deposited dust.

Metal	T.A. Luft Limits
Lead and inorganic lead compounds(as lead)	250
Cadmium and inorganic cadmium compounds (as cadmium)	5
Thallium and inorganic thallium compounds (as thallium)	10

.5.3 Methodology

The dust deposition monitoring began on 15 March, 1999 at four locations (i.e. the four compass points: NSE&W), each within 10 m – 15 m of the base of the TMF mound. The monitoring was extended to a further 8 locations (four gauges at a distance of 150 m and four gauges at a distance of 300 m) on 20 July, 1999. On 10 September, 1999, two further monitoring gauges were installed on a farm near Shallee Cross (Farm A; *see* Glossary) and these were located at distances of 300 m and 600 m from the TMF. A control site was established in Ballinmoe townland located approximately 8 km north of the TMF. A gauge was also located close to the school in Silvermines village. Map 9 shows the location of the gauges in the Silvermines area.

The gauges collect the dust fall in accordance with the German VDI method 2119 part 2:1972 (Bergerhoff gauges). The analysis determined the metal content of the deposited dust. The Bergerhoff gauges collect dust that is deposited on a monthly basis and are sufficient to identify if any significant dust events have occurred during the monitoring period. It is not possible with the Bergerhoff gauges to related hourly wind data information with monthly deposition concentrations.

.5.4 Monitoring results

A complete set of monitoring results for lead, cadmium, thallium, zinc and iron is given in Appendix 3.9. Some preliminary conclusions from the monitoring period can be drawn.

- The majority of readings obtained were well below the T.A. Luft limits. Most of the lead values are less than half the limit. Most of the cadmium results are less than one tenth and thallium less than a quarter of the respective limits. However, there were four exceedances of the T.A. Luft limit out of a total of 124 results obtained during the monitoring period. These exceedances are summarised in Table 3-4. The elevated concentrations all occurred in gauges located close to the base of the TMF.
- There is some evidence that distance from the TMF has influenced the metal content in the deposited dust. The elevated concentrations listed in the table above were all recorded at gauges that were within 20 m of the base of the TMF. The results from more distant gauges (i.e. at 150 m, 300 m and 600 m) are all within the T.A. Luft limit values.
- There is no evidence that direction relative to the tailings facility has influenced the metal content in the deposited dust. The prevailing South-Westerly wind might be expected to generate elevated dust concentrations in the gauges situated to the North and east of the facility. There is no evidence to date that wind direction influences dust deposition rates.

Table 3-4: Summary of results for metal concentrations (µg/m^2/d) for high deposition locations.

Metal	T.A. Luft limit value	*W_a 15/3/99 – 27/5/99	**W_a 20/7/99 - 20/08/99	N_a 26/11/99 - 30/12/99	E_a 28/1/00 - 29/2/00
Lead	250	498	6515	273	669
Cadmium	5	13	66.8	*0.29	*0.03
Thallium	10	Not recorded	60.0	*1.6	*7.3
* T.A. Luft values not exceeded. ** Monitoring period extended over 3-month period,					

.5.5 Conclusions

There is only limited evidence that significant concentrations of metal dust were blown from the tailing pond and deposited on land in the vicinity of the TMF during the monitoring period (i.e. land adjacent to the perimeter of the TMF to a distance of 600 m). Those instances where elevated concentrations were recorded all relate to monitoring stations that are located within 20 metres of the TMF. The corresponding results for the stations at greater distances from the TMF (i.e. 150 m, 300 m and 600 m) did not show elevated concentrations. This would suggest that dust fall remained localised.

The results for gauge W_a (20/07/99 – 20/08/99) substantially exceeds all other results. It is very likely that this result was influenced by mechanical digging that occurred during rehabilitation works on the TMF. The digging was conducted to improve the access track to the surface of the mound and was in the immediate vicinity of gauge Wa. Local Authority personnel witnessed the digging and they were of the opinion that it had affected the deposition result for the west gauge (W_a). The other high results shown in Table 3-4 are most likely the result of wind action which has caused the transportation of dust from the exposed areas of the TMF and deposited immediately in the vicinity of the TMF.

The only other anomaly in the data relates to zinc. The concentrations of zinc were consistently below 1,000µg/m^2/d with the exception for five gauges i.e. N_{300}, S_{150}, S_{300}, W_a and W_{300}, for the period July 20 to August 20, 1999. The five elevated results range from 12,770 µg/m^2/d to 48,634 µg/m^2/d and correlate with the unusually elevated lead concentrations recorded during the same period. It is therefore likely that mechanical digging on the access track during this period contributed to the exceedance of the T.A. Luft limits.

Farm A at Shallee (*see* Glossary) has been monitored for a period commencing on September 10, 1999 and therefore the assessment is limited, (i.e. monitoring points $Farm_{300}$ and $Farm_{600}$). The data available to date does not indicate any divergence from data found at other locations around the facility.

.5.6 Recommendations

- Dust deposition monitoring at these gauges should continue until the risk of dust blows is eliminated.

- Measures to prevent dust-blows as detailed in Chapter 8 should be implemented under the close supervision of TNRCC and DMNR.
- In the event of a major dust blow, a contingency plan should be drawn up and implemented under the close supervision of MWHB and TNRCC.

.6 REFERENCES

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Appendix 3.1

Table 3-5: Routine sampling locations on the Kilmastulla and Yellow rivers.

No.	Location	Included in Biological Monitoring	Included in Chemical Monitoring
0050	Kilmastulla River at Bridge in Silvermines village	4	4
0100	Kilmastulla River at Bridge North of Silvermines	6	4
0120	Kilmastulla River at Bridge West of Srah Cottage	4	6
0200	Kilmastulla River Upstream of Gortmore TMF	6	4
0300	Kilmastulla River Upstream of Yellow River confluence	4	4
0400	Stream from Garryard Mine complex	6	4
0500	Yellow River upstream of confluence with stream from Garryard (0400)	6	4
0600	Yellow River downstream of stream from Garryard	6	4
0800	Kilmastulla River at Bridge South West of Cranna House	4	4
0900	Kilmastulla River at Bridge North East of Cappadine	4	4
1,000	Kilmastulla River at Cool Bridge	4	4

Appendix 3.2

Biological Assessment of Water Quality

Biological quality ratings are based on the composition of the animal and plant communities of the river or stream and may be regarded as an index of the average water quality at any point. The degree of deterioration is assessed by comparing the results obtained with the aquatic communities living at unpolluted locations. The biological quality is conveyed by a numerical scale (Biotic Index or Q Value) of values related to water quality. This numerical biological scale is illustrated below.

Table 3-6:Biological River Quality Classification

* Biotic Index (Q value)	Water Quality	Condition	Pollution
Q5	Good	Satisfactory	Unpolluted
Q4	Fair	Satisfactory	Unpolluted
Q3	Doubtful	Unsatisfactory	Moderate
Q2	Poor	Unsatisfactory	Serious
Q1	Bad	Unsatisfactory	Serious

Intermediate ranges (e.g. Q3-4, Q4-5) are also used. Where a toxic effect is apparent or suspected the suffix '0' is added (e.g. Q 3/0).

Where pollution is present in a stream, characteristic and well documented changes are induced in the flora and fauna of the stream. Changes brought about by organic pollution in the macro-invertebrate community (i.e. the immature aquatic stages of aerial insects e.g. mayflies, stoneflies etc.) together with shrimps, snails, bivalves, worms, and leeches, are well documented. As a result of pollution, changes occur in the population density due to varying sensitivities of individual species to the presence of a pollutant. Population diversity also declines in the presence of pollution and sensitive species are progressively replaced by more tolerant species as pollution increases. The biological assessment mainly reflects the effects of biodegradable organic wastes (i.e. deoxygenation and eutrophication) however, it can also be used to show the effects of inorganic pollution e.g. heavy metal pollution. Where heavy metals such as lead, cadmium and zinc are present and impact on the invertebrates living in the streams and rivers biologists, refer to a “toxic effect” i.e. certain species, which are normally present even where organic pollution is evident, are absent from the river e.g. Gammarus or shrimps which are tolerant of organic pollution but not heavy metal pollution were present upstream of the mines i.e. at the bridge north of Silvermines (0100), however these were totally absent downstream at Cranna bridge (0800).

Appendix 3.3

Table 3-7: Biological Quality Indices for the Kilmastulla and Yellow Rivers from 1971 to 1999.

Sampling Station No.	Biological Quality Indices										
	1971	1974	1976	1978	1981	1983	1985	1987	1993	1996	1999
0050	-	-	-	-	-	-	-	-	-	-	4
0100	4-5	4	4	3-4	-	3-4	3-4	4	4	-	
0120	-	-	-	-	-	-	-	-	-	3	3-4
0300	-	3	2/0	1/0	3/0	3	-	3	-	-	-
0400[1]	-	1	1/0	1/0	1/0	-	3/0	1/0	-	-	1/0
0500[1]	-	3/0	2/0	1/0	1/0	3	3-4	3/0	-	-	3/0
0600[1]	-	1/0	1/0	1/0	1/0	3	3/0	3/0	-	-	3/0
0800	1/0	2	2-3	1/0	3/0	3-4	3/0	3-4	3/0	3/0	3
0900	3-4	3-4	3/0	3/0	3/0	3-4	4	4	3/0	3-4	3-4
1,000	5	4-5	4	3-4	4	4	4-5	4-5	3/0	3-4	4

[1] The Yellow River was included in the national biological monitoring programme until 1987. It was sampled again in 1999 for the present investigation.

Appendix 3.4

International and national standards for water

The table provides a synopsis of the water quality standards for a range of metals in water. These standards are set in various pieces of EU and National legislation to protect human health, waters and aquatic resources in Ireland. The surface water monitoring results from the Silvermines area have been compared against these standards to assess water quality in the area.

PARAMETER	UNITS	SURFACE WATER ABSTRACTION			DRINKING WATERS			FRESHWATER FISH				
		Directive 75/440/EEC A1-Treatment		Irish Standard SI No.294 of 1989	Directive 80/778/EEC		Irish Standard SI No.81 of 1988	EC Directive 78/659/EEC				Irish Salmonid Standards SI No 293 of 1988
								SALMONID		CYPRINID		
		Guide	M.A.C.		Guide	M.A.C.		Guide	M.A.C.	Guide	M.A.C.	
Iron	mg/l	0.1	0.3	0.2	0.05	0.2	0.2	---	---	---	---	---
Copper	mg/l	0.02	0.05	0.05	0.1(a)	---	0.5(a)	0.04(b)	---	0.04(b)	---	0.04(b)
Manganese	mg/l	0.05	---	0.05	0.02	0.05	0.05	---	---	---	---	---
Zinc	mg/l	0.5	3	3	0.1(a)	---	1.0(a)	---	0.3(b)	---	1.0(b)	0.3(b)
Chromium	mg/l	---	0.05	0.05	---	0.05	0.05	---	---	---	---	---
Lead	mg/l	---	0.05	0.05	---	0.05	0.05	---	---	---	---	---
Cadmium	mg/l	0.001	0.005	0.005	---	0.005	0.005	---	---	---	---	---

NOTES: M.A.C. = Maximum Admissible Concentration.

(a) Higher concentrations allowed where water has been standing in pipes - see Directive.

(b) Standards for Copper and Zinc vary with Hardness.

Appendix 3.5

Additional stream surface-water samples were taken in connection with the present investigation on 15 & 16 September, 1999, at nineteen locations. The results of analysis are listed below.

Silvermines Surface Water Samples - SW 2, SW 4 to SW 21

Sample Description		**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**
Field Sample Number		*** SW 2**	**SW 4**	**SW 5**	**SW 6**	**SW 7**
Kilkenny Lab Number		4608	4610	4611	4612	4613
Berillium	µg/l Be	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	µg/l B	<20	<20	<20	<20	<20
Sodium	mg/l Na	8.19	6.02	5.74	6.39	8.18
Magnesium	mg/l Mg	42.6	2.4	21.7	60.3	18.9
Aluminium	µg/l Al	36.3	54.9	21.4	25.0	<20
Potassium	mg/l K	1.5	0.4	0.9	0.9	1.6
Calcium	mg/l Ca	132.4	5.8	50.8	65.5	107.3
Scandium	µg/l Sc					
Vanadium	µg/l V	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/l Cr	1.1	<0.5	<0.5	0.5	1.9
Iron	µg/l Fe	1407.5	182.3	108.5	76.6	73.84
Manganese	µg/l Mn	187.3	9.9	17.5	13.4	51.24
Nickel	µg/l Ni	13.3	2.4	4.3	4.5	3.10
Cobalt	µg/l Co	1.5	0.3	<0.5	<0.5	<0.5
Copper	µg/l Cu	7.8	35.2	1.8	4.9	1.83
Zinc	µg/l Zn	2052	91	224	147	38
Germanium	µg/l Ge					
Arsenic	µg/l As	6.2	0.7	<0.5	<0.5	0.97
Selenium	µg/l Se	0.72	<0.5	<0.5	<0.5	<0.5
Molybdenum	µg/l Mo	<0.5	<0.5	0.76	<0.5	<0.5
Rhodium	µg/l Rh					
Silver	µg/l Ag	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	µg/l Cd	10.1	0.7	0.7	0.5	0.72
Tin	µg/l Sn					
Antimony	µg/l Sb	2.3	0.6	<0.5	<0.5	1.17
Barium	µg/l Ba	83.2	321.2	254.1	120.5	192.24
Rhenium	µg/l Re					
Mercury	µg/l Hg					
Thallium	µg/l Tl	6.3	<0.5	<0.5	<0.5	<0.5
Lead	µg/l Pb	193.6	80.8	6.6	10.0	25.0
Thorium	µg/l Th	<0.5	<0.5	<0.5	<0.5	<0.5
Uranium	µg/l U	1.0	<0.5	<0.5	<0.5	<0.5

* SW1 and SW3 are surface water samples taken from the Garryard mine complex(see Appendix 3.8).

Surface Water Samples - SW 2, SW 4 to SW 21

Samples taken on 15-16 September, 1999

Sample Description		**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**
Field Sample Number		**SW 8**	**SW 9**	**SW 10**	**SW 11**	**SW 12**	**SW 13**	**SW 14**
Kilkenny Lab Number		4668	4669	4670	4671	4672	4673	4674
Berillium	µg/l Be	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	µg /l B	<20	<20	25.26	<20	<20	<20	<20
Sodium	mg/l Na	7.7	8.4	8.5	8.2	8.5	7.0	8.8
Magnesium	mg/l Mg	3.6	5.5	10.5	5.5	6.8	18.9	10.6
Aluminium	µg /l Al	91	221	58	183	205	22	162
Potassium	mg/l K	0.9	2.7	2.6	2.3	2.4	1.5	4.2
Calcium	mg/l Ca	17	59	106	54	63	79	74
Scandium	µg /l Sc							
Vanadium	µg /l V	<0.5	0.55	<0.5	<0.5	0.54	<0.5	0.59
Chromium	µg /l Cr	0.5	1.5	2.0	1.3	1.4	0.9	1.4
Iron	µg /l Fe	453	457	229	662	535	381	540
Manganese	µg /l Mn	57	43	123	45	63	109	93
Nickel	µg /l Ni	2.0	2.6	3.2	3.1	3.1	4.2	3.4
Cobalt	µg /l Co	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Copper	µg /l Cu	1.5	1.6	2.9	7.4	4.0	2.7	3.9
Zinc	µg /l Zn	72	12	114	68	104	103	93
Germanium	µg /l Ge							
Arsenic	µg /l As	<0.5	0.7	0.9	0.8	0.9	<0.5	1.1
Selenium	µg/l Se	<0.5	<0.5	0.7	<0.5	<0.5	<0.5	<0.5
Molybdenum	µg /l Mo	<0.5	<0.5	<0.5	<0.5	<0.5	0.51	<0.5
Rhodium	µg /l Rh							
Silver	µg /l Ag	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	µg /l Cd	0.22	0.09	0.33	0.23	0.32	0.21	0.26
Tin	µg /l Sn	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Antimony	µg /l Sb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Barium	µg /l Ba	45	106	222	107	121	113	155
Rhenium	µg /l Re							
Mercury	µg /l Hg							
Thallium	µg /l Tl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Lead	µg /l Pb	10	2.4	2.3	22	45	3.4	28
Thorium	µg /l Th	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Uranium	µg /l U	<0.5	<0.5	1.59	<0.5	<0.5	<0.5	<0.5

Surface Water Samples - SW 2, SW 4 to SW 21

Samples taken on 15-16 September, 1999

Sample Description		**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**
Field Sample Number		**SW 15**	**SW 16**	**SW 17**	**SW 18**	**SW 19**	**SW 20**	**SW 21**
EPA Kilkenny Number		4675	4676	4677	4678	4679	4680	4681
Berillium	µg /l Be	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	µg /l B	<20	<20	<20	<20	<20	<20	<20
Sodium	Mg/l Na	8.8	6.2	6.3	6.7	6.3	6.7	8.5
Magnesium	Mg/l Mg	12.2	10.3	3.2	11.0	2.7	3.5	10.3
Aluminium	µg/l Al	210	121	67	129	104	89	197
Potassium	Mg/l K	3.8	0.6	0.4	0.8	1.2	1.5	3.8
Calcium	Mg/l Ca	69	21	12	33	17	26	63
Scandium	µg/l Sc							
Vanadium	µg/l V	0.74	<0.5	<0.5	<0.5	<0.5	<0.5	0.63
Chromium	µg/l Cr	1.5	<0.5	<0.5	0.5	<0.5	0.6	1.2
Iron	µg/l Fe	1424	952	260	821	296	552	706
Manganese	µg/l Mn	173	79	99	143	36	137	134
Nickel	µg/l Ni	5.9	6.1	8.7	9.3	2.8	3.8	4.7
Cobalt	µg/l Co	0.9	0.8	1.8	1.5	<0.5	0.6	0.7
Copper	µg/l Cu	9.2	34.3	11.3	30.7	2.1	4.9	8.0
Zinc	µg/l Zn	424	802	585	1298	27	38	299
Germanium	µg/l Ge							
Arsenic	µg/l As	2.9	2.5	0.9	3.0	<0.5	1.0	1.7
Selenium	µg/l Se	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Molybdenum	µg/l Mo	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Rhodium	µg/l Rh							
Silver	µg/l Ag	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	µg/l Cd	1.7	3.6	2.2	5.3	0.21	0.32	1.01
Tin	µg/l Sn	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Antimony	µg/l Sb	0.63	0.68	1.3	1.3	<0.5	0.61	<0.5
Barium	µg/l Ba	267	242	287	279	272	316	188
Rhenium	µg/l Re							
Mercury	µg/l Hg							
Thallium	µg/l Tl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Lead	µg/l Pb	124	130	313	307	34	49	81
Thorium	µg/l Th	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Uranium	µg/l U	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Appendix 3.6

Stream Sediment Samples SS1 – SS 19

Samples taken 15-16 September, 1999

Sample Description		**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**
Field Sample Number		**SS 1**	**SS 2**	**SS 3**	**SS 4**	**SS 5**	**SS 6**	**SS 7**
EPA Kilkenny Lab No.		4630	4631	4632	4633	4634	4654	4655
Berillium	mg/kg Be	2.0	1.8	< 1.0	1.5	2.2	1.3	< 1.1
Boron	mg/kg B	< 22	21.3	<21	< 21	24.9	< 21.5	< 21.5
Sodium	mg/kg Na	1116	942	740	630	677	555	445
Magnesium	mg/kg Mg	3759	3066	2522	1266	5532	3009	5890
Aluminium	mg/kg Al	8079	11024	5520	8425	20624	11471	11956
Potassium	mg/kg K	1082	2100	891	1403	4523	1885	2797
Calcium	mg/kg Ca	14078	4871	6979	3148	13610	3114	86336
Scandium	mg/kg Sc							
Vanadium	mg/kg V	8.7	17.7	12.7	17.0	28.4	17.3	14.1
Chromium	mg/kg Cr	15.4	17.8	10.0	14.5	26.2	18.0	16.2
Iron	mg/kg Fe	164258	41604	21853	27389	21326	38206	25739
Manganese	mg/kg Mn	14994	1154	831	1708	244	1576	436
Nickel	mg/kg Ni	566	73	44	58	64	68	42
Cobalt	mg/kg Co	147	18	13	16	9	13	7
Copper	mg/kg Cu	642	503	63	151	94	19	15
Zinc	mg/kg Zn	208233	3613	817	876	475	1228	528
Germanium	mg/kg Ge							
Arsenic	mg/kg As	468	259	24	34	8	27	17.8
Selenium	mg/kg Se	7.2	< 1.1	< 1.0	< 1.0	-1.2	< 1.1	< 1.1
Molybdenum	mg/kg Mo	3.1	< 1.1	1.8	3.7	-1.2	< 1.1	< 1.1
Rhodium	mg/kg Rh							
Silver	mg/kg Ag	11.0	8.2	< 1.0	1.1	2.1	< 1.1	< 1.1
Cadmium	mg/kg Cd	195.8	19.3	2.6	2.7	5.5	3.2	1.3
Tin	mg/kg Sn	0.0	0.0	0.0	0.0	0.0		
Antimony	mg/kg Sb	37.2	18.7	1.5	1.8	2.1	< 1.1	< 1.1
Barium	mg/kg Ba	2813	4498	4232	1100	634	671	312
Rhenium	mg/kg Re							
Mercury	mg/kg Hg							
Thallium	mg/kg Tl	22.8	< 1.1	< 1.0	< 1.0	< 1.2	< 1.1	< 1.1
Lead	mg/kg Pb	12332	5853	797	3327	1780	1466	627
Thorium	mg/kg Th	< 1.1	< 1.1	< 1.0	< 1.0	2.6	< 1.1	< 1.1
Uranium	mg/kg U	19.5	< 1.1	< 1.0	1.7	< 1.2	< 1.1	< 1.1

Stream Sediment Samples

Samples taken 15-16 September, 1999

Sample Description		**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**
Field Sample Number		**SS 8**	**SS 9**	**SS 10**	**SS 11**	**SS 12**	**SS 13**	**SS 14**
EPA Kilkenny Lab No.		4656	4657	4658	4659	4660	4661	4662
Berillium	mg/kg Be	2.2	1.6	1.8	1.9	1.4	< 1.1	2.1
Boron	mg/kg B	27.6	< 22.5	21.3	< 22.0	24.3	21.4	< 22.0
Sodium	mg/kg Na	941	686	587	547	491	533	666
Magnesium	mg/kg Mg	4294	4218	4261	1382	5153	5095	3206
Aluminium	mg/kg Al	19949	11401	13283	11525	17314	15733	15300
Potassium	mg/kg K	3721	1820	2348	2115	3320	2152	2953
Calcium	mg/kg Ca	23970	33564	27609	3423	42207	1991	5989
Scandium	mg/kg Sc							
Vanadium	mg/kg V	26.4	14.7	23.0	23.4	22.0	17.3	24.7
Chromium	mg/kg Cr	27.2	15.5	25.2	18.0	24.9	24.8	21.2
Iron	mg/kg Fe	45616	39569	31643	35672	17314	28019	38863
Manganese	mg/kg Mn	1058	1061	555	1851	476	369	1236
Nickel	mg/kg Ni	82.5	59.4	92.4	77.9	65.4	49.4	79.9
Cobalt	mg/kg Co	14.5	10.3	12.0	20.3	12.4	8.9	20.1
Copper	mg/kg Cu	41.8	21.4	32.2	120.9	30.6	13.5	733.3
Zinc	mg/kg Zn	5488	4110	4768	876	1607	98	4396
Germanium	mg/kg Ge							
Arsenic	mg/kg As	43.6	52.3	50.7	46.8	23.9	3.0	150.0
Selenium	mg/kg Se	1.24	< 1.1	1.3	< 1.1	< 1.1	< 1.1	1.63
Molybdenum	mg/kg Mo	< 1.1	< 1.1	0.0	2.97	< 1.1	< 1.1	1.83
Rhodium	mg/kg Rh			0.0				
Silver	mg/kg Ag	1.7	3.7	2.3	< 1.1	< 1.1	< 1.1	6.7
Cadmium	mg/kg Cd	17.9	8.2	18.2	3.3	6.7	0.4	16.1
Tin	mg/kg Sn			1269				
Antimony	mg/kg Sb	1.8	2.4	2.3	1.9	< 1.1	< 1.1	13.8
Barium	mg/kg Ba	1026	1009	852	1565	818	189	4166
Rhenium	mg/kg Re							
Mercury	mg/kg Hg							
Thallium	mg/kg Tl	< 1.1	< 1.1	0.6	1.45	< 1.1	< 1.1	2.80
Lead	mg/kg Pb	2776	3342	3037	1306	1028	57	9454
Thorium	mg/kg Th	< 1.1	< 1.1	0.8	< 1.1	1.21	< 1.1	< 1.1
Uranium	mg/kg U	< 1.1	< 1.1	1.1	1.29	< 1.1	< 1.1	1.44

Stream Sediment Samples

Samples taken 15-16 September, 1999

Sample Description		**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**	**Stream Sediment**
Field Sample Number		**SS 15**	**SS 16**	**SS 17**	**SS 18**	**SS 19**
EPA Kilkenny Lab No.		4663	4664	4665	4666	4667
Berillium	mg/kg Be	< 1.1	1.7	< 1.1	< 1.1	1.4
Boron	mg/kg B	< 22.0	< 23	< 21.0	< 21	25.2
Sodium	mg/kg Na	550	695	437	456	714
Magnesium	mg/kg Mg	2976	4134	1753	951	6091
Aluminium	mg/kg Al	8174	12551	5762	5922	18534
Potassium	mg/kg K	1674	2537	1217	1151	3658
Calcium	mg/kg Ca	8120	9472	7803	3657	21883
Scandium	mg/kg Sc					
Vanadium	mg/kg V	10.8	20.5	10.2	8.8	21.2
Chromium	mg/kg Cr	10.8	17.9	9.9	9.1	24.5
Iron	mg/kg Fe	20127	41678	25641	21312	28308
Manganese	mg/kg Mn	345	1091	1041	603	564
Nickel	mg/kg Ni	68.0	77.0	45.8	31.4	53.9
Cobalt	mg/kg Co	17.5	16.3	6.9	6.7	12.5
Copper	mg/kg Cu	102.5	421.1	22.0	46.2	31.5
Zinc	mg/kg Zn	1036	3575	261	355	484
Germanium	mg/kg Ge					
Arsenic	mg/kg As	195.8	204.8	19.3	18.4	18.9
Selenium	mg/kg Se	< 1.1	1.19	< 1.1	< 1.1	< 1.1
Molybdenum	mg/kg Mo	< 1.1	2.24	< 1.1	< 1.1	< 1.1
Rhodium	mg/kg Rh					
Silver	mg/kg Ag	13.4	9.4	< 1.1	< 1.1	< 1.1
Cadmium	mg/kg Cd	2.9	9.7	1.7	2.3	2.3
Tin	mg/kg Sn					
Antimony	mg/kg Sb	20.8	19.3	1.7	1.6	< 1.1
Barium	mg/kg Ba	7661	6630	3290	606	925
Rhenium	mg/kg Re					
Mercury	mg/kg Hg					
Thallium	mg/kg Tl	< 1.1	2.80	< 1.1	< 1.1	< 1.1
Lead	mg/kg Pb	12242	9184	684	889	459
Thorium	mg/kg Th	< 1.1	< 1.1	< 1.1	< 1.1	2.19
Uranium	mg/kg U	< 1.1	1.19	< 1.1	< 1.1	< 1.1

Appendix 3.7

Garryard Tailings Lagoon and Settlement Sludge Analysis T1 – T 6

Samples taken 15-16 September, 1999

Sample Description		**Tailings lagoon Sludge**	**Tailings lagoon Sludge**	**Tailings lagoon Sludge**	**Tailings lagoon Sludge**	**Settlement pond Sludge**	**Settlement pond Sludge**
Field Sample Number		**T 1**	**T 2**	**T 3**	**T 4**	**T 5**	**T 6**
EPA Kilkenny Lab No.		4621	4622	4623	4624	4625	4626
Berillium	mg/kg Be	2.2	1.9	2.1	2.4	1.1	2.4
Boron	mg/kg B	36	30	22	40	26	41
Sodium	mg/kg Na	1040	1141	686	1109	635	1026
Magnesium	mg/kg Mg	18202	17437	8848	15781	20168	20339
Aluminium	mg/kg Al	12678	9131	6353	10291	3626	9647
Potassium	mg/kg K	3208	2702	1416	3174	1026	3023
Calcium	mg/kg Ca	98633	118614	84816	133990	59640	99904
Scandium	mg/kg Sc						
Vanadium	mg/kg V	22	19	14	21	8	17
Chromium	mg/kg Cr	20	16	11	226	8	17
Iron	mg/kg Fe	148898	112246	143294	86267	233348	134119
Manganese	mg/kg Mn	1662	1554	3345	1800	1859	2267
Nickel	mg/kg Ni	264	194	191	208	305	220
Cobalt	mg/kg Co	16	15	13	18	13	16
Copper	mg/kg Cu	487	511	167	742	169	336
Zinc	mg/kg Zn	94458	80003	88719	86537	58290	45047
Germanium	mg/kg Ge						
Arsenic	mg/kg As	584	503	550	331	1292	800
Selenium	mg/kg Se	8.5	18.9	3.7	5.9	5.1	5.8
Molybdenum	mg/kg Mo	4.6	4.0	2.2	3.8	3.8	3.8
Rhodium	mg/kg Rh						
Silver	mg/kg Ag	41	47	13	34	23	25
Cadmium	mg/kg Cd	310	327	293	273	224	169
Tin	mg/kg Sn	0	0	0	0	0	0
Antimony	mg/kg Sb	140	219	67	121	167	130
Barium	mg/kg Ba	684	558	388	963	299	619
Rhenium	mg/kg Re						
Mercury	mg/kg Hg						
Thallium	mg/kg Tl	49	50	55	39	136	65
Lead	mg/kg Pb	37857	51230	14085	34883	27114	29818
Thorium	mg/kg Th	< 1.0	< 1.0	< 1.0	< 1.2	< 1.1	< 1.2
Uranium	mg/kg U	4.0	2.7	1.3	3.5	< 1.1	2.4

Shallee Tailings Samples T7 – T9

Samples taken on 15-16 September, 1999

Sample Description		**Shallee Tailings**	**Shallee Tailings**	**Shallee Tailings**
Field Sample Number		**T 7**	**T 8**	**T 9**
EPA Kilkenny Lab No.		**4627**	**4628**	**4629**
Berillium	mg/kg Be	< 1.1	2.1	< 1.1
Boron	mg/kg B	< 22	24.1	< 21
Sodium	mg/kg Na	643	1046	723
Magnesium	mg/kg Mg	187	1755	336
Aluminium	mg/kg Al	3556	15467	4100
Potassium	mg/kg K	941	4373	1079
Calcium	mg/kg Ca	774	4686	1116
Scandium	mg/kg Sc			
Vanadium	mg/kg V	3.0	18.1	4.7
Chromium	mg/kg Cr	6.6	42.4	14.8
Iron	mg/kg Fe	15217	29954	17734
Manganese	mg/kg Mn	625	1252	195
Nickel	mg/kg Ni	56	99	25
Cobalt	mg/kg Co	14	23	5
Copper	mg/kg Cu	41	62	38
Zinc	mg/kg Zn	222	267	101
Germanium	mg/kg Ge			
Arsenic	mg/kg As	251	142	83
Selenium	mg/kg Se	< 1.1	< 1.1	< 1.1
Molybdenum	mg/kg Mo	< 1.1	< 1.1	< 1.1
Rhodium	mg/kg Rh			
Silver	mg/kg Ag	6.2	7.8	5.2
Cadmium	mg/kg Cd	1.6	1.6	0.4
Tin	mg/kg Sn	0.0	0.0	0.0
Antimony	mg/kg Sb	11	12	16
Barium	mg/kg Ba	9166	14869	8903
Rhenium	mg/kg Re			
Mercury	mg/kg Hg			
Thallium	mg/kg Tl	< 1.1	< 1.1	< 1.1
Lead	mg/kg Pb	3453	3843	3240
Thorium	mg/kg Th	< 1.1	1.6	< 1.1
Uranium	mg/kg U	< 1.1	< 1.1	< 1.1

Appendix 3.8

Garryard Surface Water Samples - SW 1 & SW 3

Samples taken on 15-16 September, 1999

Sample Description		**Tailings lagoon**	**Settlement Pond**
Field Sample Number		**SW 1**	**SW 3**
EPA Kilkenny Lab No.		4607	4609
Berillium	µg//l Be	<0.5	<0.5
Boron	µg/l B	<20	<20
Sodium	mg/l Na	7.93	6.49
Magnesium	mg/l Mg	42.6	34.8
Aluminium	µg/l Al	81.3	<20
Potassium	mg/l K	1.6	1.6
Calcium	mg/l Ca	131.6	110.1
Scandium	µg/l Sc		
Vanadium	µg/l V	<0.5	<0.5
Chromium	µg/l Cr	1.0	0.9
Iron	µg/l Fe	3346.1	781.8
Manganese	µg/l Mn	178.5	195.7
Nickel	µg/l Ni	16.5	8.9
Cobalt	µg/l Co	1.4	0.8
Copper	µg/l Cu	15.1	3.3
Zinc	µg/l Zn	2717	1286
Germanium	µg/l Ge		
Arsenic	µg/l As	12.0	1.5
Selenium	µg/l Se	0.70	0.52
Molybdenum	µg/l Mo	<0.5	<0.5
Rhodium	µg/l Rh		
Silver	µg/l Ag	<0.5	<0.5
Cadmium	µg/l Cd	11.3	4.4
Tin	µg/l Sn		
Antimony	µg/l Sb	3.5	2.5
Barium	µg/l Ba	97.6	57.4
Rhenium	µg/l Re		
Mercury	µg/l Hg		
Thallium	µg/l Tl	6.2	4.6
Lead	µg/l Pb	372.8	118.0
Thorium	µg/l Th	<0.5	<0.5
Uranium	µg/l U	1.1	<0.5

Appendix 3.9

Table 3-8: Summary of dust monitoring results

Monitoring period	No. of days	Sample location	µg/m^2/day				
			Lead	Cadmium	Thallium	Zinc	Iron
15/03/99 – 27/05/99	73	N_a	107	1.2	-	463	27.6
		S_a	46	0.1	-	619	12.6
		E_a	59	0.3	-	481	14.1
		W_a	498	13	-	1109	104
27/05/99 – 28/06/99	32	N_a	118	<0.5	-	136	2266
		S_a	123	4.9	-	522	3941
		E_a	48	<0.5	-	545	950
		W_a	68	<0.5	-	316	2938
20/07/99 – 20/08/99	31	N_a	36	0.4	<2.7	295	1012
		N_{150}	7.6	<0.3	<2.7	309	431
		N_{300}	4.8	<0.3	<2.7	13817	305
		S_a	10.7	<0.3	<2.7	389	342
		S_{150}	17.3	<0.3	<2.7	13893	478
		S_{300}	24.4	<0.3	<2.7	48634	25415
		E_a	48.5	<0.3	<2.7	145	1066
		E_{150}	6.5	<0.3	<2.7	918	319
		E_{300}	6.5	<0.3	<2.7	145	256
		W_a	6815	66.8	60	12770	746312
		W_{150}	16.4	<0.3	<2.7	207	622
		W_{300}	12.3	0.9	<2.7	17398	807
20/08/99 – 21/09/99	32	N_a	35.1	<0.3	<2.6	161	713
		N_{150}	5.6	<0.3	<2.6	207	236
		N_{300}	80.8	0.6	<2.6	538	13144
		S_a	9.7	<0.3	<2.6	191	325
		S_{150}	175	<0.3	<2.6	111	209
		S_{300}	29.9	<0.3	<2.6	52	95
		E_a	48.1	<0.3	<2.6	211	887
		E_{150}	13.9	<0.3	<2.6	193	254
		E_{300}	72.3	<0.3	<2.6	202	396
		W_a	95.7	0.6	<2.6	341	1719
		W_{150}	7.7	<0.3	<2.6	224	386
		W_{300}	4.6	<0.3	<2.6	119	381
10/09/99 – 21/09/99	11	Farm $_{300}$	9.0	<0.7	<7.5	408	1527
		Farm $_{600}$	15.1	<0.7	<7.5	260	1219
21/09/99 – 27/10/99	37	N_a	4.2	< 0.22	< 2.2	100	194
		N_{150}	52.5	< 0.22	< 2.2	174	197
		N_{300}	28.8	< 0.22	< 2.2	245	637
		S_a	7.5	< 0.22	< 2.2	101	194
		S_{150}	< 2.2	< 0.22	< 2.2	79	149
		S_{300}	3.7	< 0.22	< 2.2	37	117
		E_a	49.3	< 0.22	< 2.2	899	835
		E_{150}	2.9	< 0.22	< 2.2	103	156
		E_{300}	7.3	< 0.22	< 2.2	115	178
		W_a	8.0	< 0.22	< 2.2	186	253

		W_{150}	10.4	< 0.22	< 2.2	153	139
		W_{300}	< 2.2	< 0.22	< 2.2	175	124

Appendix 3.9 contd.

Monitoring period	No. of days	Sample location	$\mu g/m^2/d$				
			Lead	Cadmium	Thallium	Zinc	Iron
		Farm $_{300}$	2.7	< 0.22	< 2.2	117	128
		Farm $_{600}$	14.5	< 0.22	< 2.2	88	596
27/10/99 – 26/11/99	30	N_a	91	< 2.7	< 2.7	264	2137
		N_{150}	< 2.7	< 2.7	< 2.7	102	342
		N_{300}	3.2	< 2.7	< 2.7	201	433
		S_a	2.7	< 2.7	< 2.7	138	320
		S_{150}	23	< 2.7	< 2.7	199	483
		S_{300}	17.6	< 2.7	< 2.7	232	374
		E_a	47	< 2.7	< 2.7	154	1088
		E_{150}	<2.7	< 2.7	< 2.7	135	424
		E_{300}	41	< 2.7	< 2.7	237	1279
		W_a	23	< 2.7	< 2.7	134	672
		W_{150}	<2.7	< 2.7	< 2.7	175	351
		W_{300}	4.4	< 2.7	< 2.7	583	546
		Farm $_{300}$	<2.7	< 2.7	< 2.7	938	313
		Farm $_{600}$	43	< 2.7	< 2.7	154	2492
01/11/99 – 26/11/99	26	Control	<3.1	< 3.1	< 3.1	223	604
26/11/99 – 30/12/99	34	N_a	273	0.29	1.6	284	4488
		N_{150}	3.4	0.21	< 0.4	156	95
		N_{300}	82	0.11	< 0.4	238	189
		S_a	10.9	0.23	< 0.4	61	92
		S_{150}	9.4	0.99	< 0.4	220	188
		S_{300}	13.1	0.13	< 0.4	856	123
		E_a	240	<0.02	1.7	120	4653
		** E_{150}	-	-	-	-	-
		E_{300}	3.6	0.19	< 0.24	97	141
		W_a	150	0.14	1.6	952	3183
		W_{150}	108	0.15	< 0.24	153	142
		W_{300}	95	0.08	< 0.24	80	1178
		Farm $_{300}$	9.9	<0.02	< 0.24	107	1153
		Farm $_{600}$	30.6	<0.02	< 0.24	113	1129
		Control	2.04	<0.02	< 0.24	156	1104
31/12/99 – 28/01/2,000	28	N_a	18.9	<0.029	<0.29	85	791
		N_{150}	3.3	<0.029	<0.29	53	107
		N_{300}	7.9	<0.029	<0.29	99	268
		S_a	5.1	<0.029	<0.29	104	211
		S_{150}	2.1	<0.029	<0.29	84	214
		S_{300}	9.1	<0.029	<0.29	366	227
		E_a	11.1	<0.029	<0.29	572	375
		E_{150}	9.3	<0.029	<0.29	461	4111
		E_{300}	8.4	<0.029	<0.29	94	265
		W_a	6.0	<0.029	<0.29	76	288
		W_{150}	53.0	<0.029	<0.29	118	249
		W_{300}	1.7	<0.029	<0.29	303	1303
		Farm $_{300}$	1.6	<0.029	<0.29	63	140
		Farm $_{600}$	44.7	<0.029	<0.29	91	646
		Control	1.1	<0.029	<0.29	116	256

28/01/00 – 29/02/00	32	N_a	142	0.09	1.52	199	2821
		N_{150}	1.6	<0.026	<0.26	114	203

Appendix 3.9 contd.

Monitoring period	No. of days	Sample location	Lead	Cadmium	Thallium	Zinc	Iron
		N_{300}	4.2	<0.026	<0.26	183	274
		S_a	3.2	<0.026	<0.26	170	351
		S_{150}	2.9	<0.026	<0.26	138	291
		S_{300}	2.7	<0.026	<0.26	55	254
		E_a	669	<0.026	<0.26	223	12,084
		E_{150}	6.3	<0.026	<0.26	88	248
		E_{300}	7.6	<0.026	<0.26	119	371
		***W_a	-	-	-	-	-
		W_{150}	1.7	<0.026	<0.26	187	477
		W_{300}	1.2	<0.026	<0.26	130	293
		Farm $_{300}$	2.8	<0.026	<0.26	122	218
		Farm $_{600}$	30	<0.026	<0.26	91	1737
		Control	1.8	<0.026	<0.26	105	305
29/02/00 – 27/03/00	28	N_a	4.7	1.23	<0.29	66.9	1116
		N_{150}	2.5	0.05	<0.29	132.2	714
		N_{300}	3.6	<0.029	<0.29	81.6	495
		S_a	3.6	<0.029	<0.29	98.7	892
		S_{150}	3.0	<0.029	<0.29	137	841
		S_{300}	46	1.04	<0.29	42.8	717
		E_a	82.5	<0.029	<0.29	85.4	3048
		E_{150}	2.2	<0.029	<0.29	106.2	749
		E_{300}	8.5	<0.029	<0.29	105.8	846
		W_a	48.8	<0.029	0.9	91.8	1773
		W_{150}	30.4	1.89	<0.29	140.5	931
		W_{300}	2.9	1.02	<0.29	80.4	773
		School	21.5	3.13	<0.29	298.7	1313
		Farm $_{300}$	4.2	1.03	<0.29	92.3	784
		Farm $_{600}$	4.1	0.94	<0.29	36.2	847
		Control	5.0	1.03	<0.29	74.9	1141

* Gap in monitoring results occurred when changing from 4 gauges to 12 gauges.
** No sample for E $_{150}$ received for period 26/11/99 – 30/12/99
*** Sample jar for W_a was broken in transit.

Chapter 4

Lead In Soils, Herbage, Fodder, And Water

.1 INTRODUCTION

The objectives of this component of the investigation were:

- To determine heavy metal (lead, zinc, cadmium, copper and arsenic) concentrations in soil, herbage, water, silage and hay samples taken from agricultural lands in the Silvermines area.
- To evaluate the severity and extent of environmental pollution.

.2 SOILS OF THE SILVERMINES AREA

Soils of the Silvermines area are entirely devoted to grassland agriculture, predominantly dairying and dry stock. They have been classified by Finch and Gardiner in their Soil Survey of Tipperary North Riding[1]. The classification process includes division into soil type and potential for grassland production. Class A soils are potentially the most productive with Class E being the least. A small proportion of soils are assigned to Class V (variable restrictions). These generally have severe limitations for production.

In summary, the three soil series, Borrisoleigh, Borrisoleigh-Ballinalackan and Elton (Map 10) comprise more than half of the area selected for chemical examination in this investigation. All these soils are Class A, high yielding with only minor use limitations. Two soils are designated Class C with wetness a major limitation in both the Knockastanna and Banagher series. Other soils, Class D, E and V tend to have even more severe restrictions such as susceptibility to flooding, elevation and slope in addition to wetness. They may be suited only to extensive grazing, or to occasional grazing or cutting for hay in summer. Thus the soils in the Silvermines area are, in general, productive but include areas where agricultural use is severely restricted.

.3 LEAD AND OTHER METALS IN SOIL

All soils contain heavy metals in measurable amounts. The heavy metal concentrations of Irish agricultural soils are summarised in Table 4-1.

Table 4-1: The heavy metal concentrations (mg/kg) of Irish agricultural soils (McGrath and McCormack, 1999)[2].

Heavy Metal	50 Percentile*	95 Percentile*
Lead	26.5	59.3
Copper	14.9	34.2
Zinc	43.7	134.1
Arsenic	11.9	42
Cadmium	0.39	1.48

*50% and 95% of agricultural soils, respectively, have values less than this.

Most agricultural soils in Ireland contain about 25 mg/kg of lead, slightly less copper and arsenic, and slightly more zinc. Cadmium is generally less than 1 mg/kg. Of the above, copper and zinc are essential for adequate plant and animal performance. Lead and cadmium have no beneficial effects but are not toxic at the above 95 percentile concentrations in soil (Table 4-1).

.4 IMPACT OF LEAD AND ZINC MINING ON GRASSLAND AGRICULTURE

Mining has left a strong imprint on the landscape and soil in many countries. As a consequence, crops including grass, are exposed to elevated amounts of heavy metals. Plant growth may be adversely affected and the quality of the crop for animal and human consumption may be diminished[3].

The situation in Silvermines is not unlike that in parts of the UK[4,5] and US[6]. In these areas, grassland agriculture is being conducted on soils with highly elevated concentrations of lead and zinc and, in some instances, cadmium and copper. Long after the cessation of mining there have been reports of animal deaths as a consequence of lead poisoning[4].

There is a real difficulty in determining the probable impact of pollution from lead on agriculture. In general, farmers live with the problem by adopting sound husbandry practice i.e. by denying animals access to herbage when it appears to be contaminated. This strategy has been articulated in a number of publications[3,6,7] and is based largely on a knowledge of the pathways by which lead travels from soil to animal. A value of 1,000 mg/kg of lead has been suggested as a threshold below which toxicity problems are unlikely to occur in grazing animals[7]. This is believed to be a conservative value having regard to the physical and chemical properties of lead in soil and to the amounts required to produce toxic symptoms in cattle[12]. It should, however, be realised that quantitative data of a dose-response nature (i.e. what animal health effect can be anticipated from given concentrations of lead in soils under defined field conditions) is almost entirely non-existent. However, Thornton and Kinniburgh, in a survey of 11 farms in Derbyshire[8], demonstrated a broad relationship that showed blood lead of cattle rising from 100 to 300 μg/l as soil concentrations rose from 100 – 400 to 1,000-2,000 mg/kg.

.5 LEAD POLLUTION INCIDENTS IN SILVERMINES - 1985

In the aftermath of dust blows early in 1985, Teagasc (An Foras Taluntais and ACOT) personnel visited farms adjacent to the Gortmore TMF on five occasions throughout that year. Eighty-six soil samples and 50 herbage/fodder samples were taken and analysed for lead and occasionally for other metals.

On one farm adjacent to the Gortmore TMF evidence for polluting events(s) involving dust blow was obtained. Soil lead concentrations were low for the area and decreased with depth, an indication of aerial deposition. Lead on herbage exceeded 1,000 mg/kg on occasion. Such an amount on forage or fodder would be expected to represent a major risk to cattle or other animals.

Soil lead values ranged from near normal (less than 100 mg/kg) to nearly 20,000 mg/kg in a later survey (November, 1985) of other farms in the Silvermines area. Associated herbage lead concentrations were comparatively modest, rarely exceeding 100 mg/kg and were often less than 10 mg/kg.

In an earlier incident in the West of Ireland, 50% of the herbages in an area which was affected by dust from mining activity had lead values in excess of 500 mg/kg[9].

.6 SCOPE OF THE CURRENT INVESTIGATION

The scope of the investigation was to measure the amount of lead and other relevant heavy metals in

- Soils
- Grazed herbage
- Conserved fodder
- Drinking water

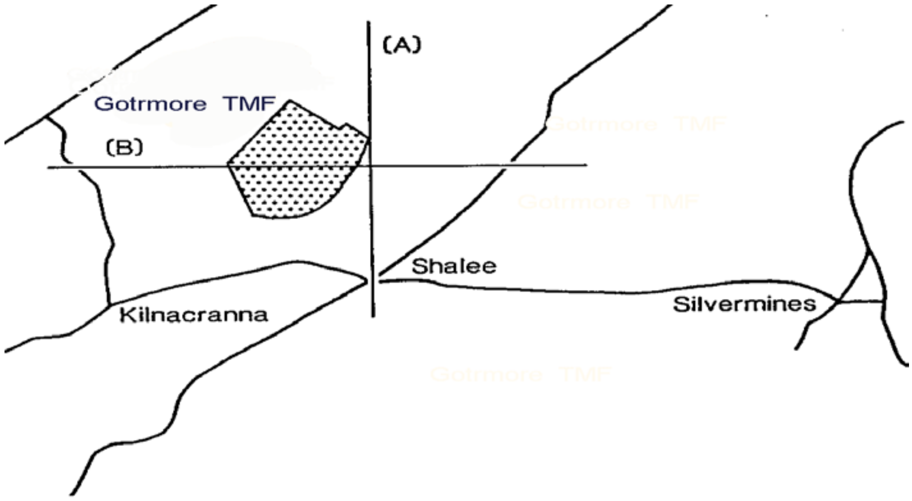
on farms within the designated study area.

.7 INVESTIGATIONS AND METHODOLOGY

The investigation included the following stages:

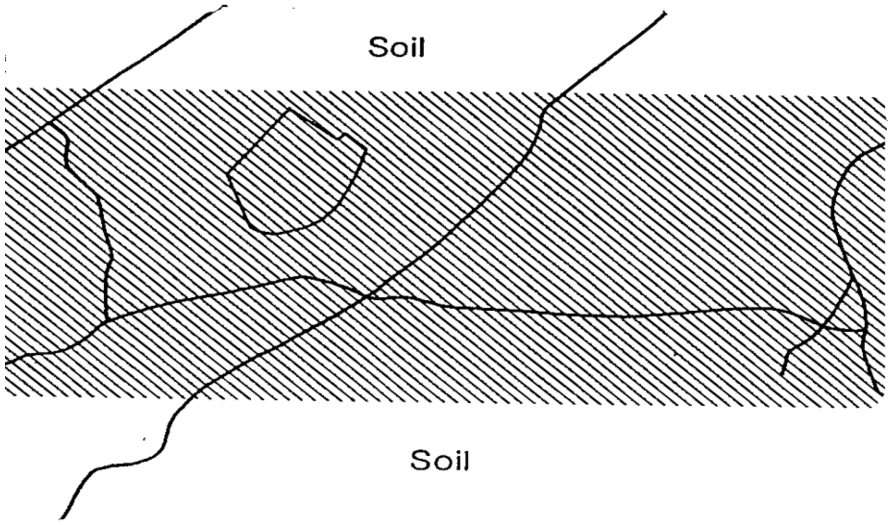
- An exploratory investigation of soils and herbages on two transects, one oriented North-South and one East-West, was conducted first. The survey covered the Gortmore TMF and low-lying adjacent areas (Figure 4-1). A total of 34 soils (0 - 10 cm samples) and 33 associated herbages (one tailings pond sampling area had no vegetation) were collected at regular intervals of 200 m along each transect. These included 29 soils under grassland agriculture and five from Gortmore TMF. Soils were analysed[10] for lead, zinc, cadmium, copper, and arsenic. Herbage was analysed for a similar range of heavy metals and also for botanical species composition.

Figure 4-1: location of sampling transects (A) and (B) used in the exploratory investigation.



- An extensive investigation of soil and herbages was conducted in September/October, 1999. The sampled area extended about 3 km north and 2 km south of an east-west line from Silvermines village to Kilnacranna (Figure 4-2). Samples (to a depth of 0-10 cm) were collected on a grid at intervals of 400 m. A grab sample of herbage, cut to within 50 mm of the soil surface, was taken at each soil sampling point. A total of 223 soils and 218 associated herbages within an area of 4.0 x 4.8 km were collected. Analyses were performed on all soils for lead, zinc, copper and cadmium and for pH and loss on ignition (organic matter content). Analyses were performed on 119 of these herbage samples (Figure 4-2) for lead, zinc, copper, and cadmium and for iron (a useful indicator of the extent of contamination of herbage by soil).
- A total of 51 silages and 23 hays was obtained from 54 farms in the problem area. Samples were analysed for lead, zinc, copper, cadmium, molybdenum and iron.

Figure 4-2: Outline of main soil sampling area. Herbage samples from within the shaded area were selected for analysis.



- Samples of animal drinking water from farms were collected at functioning outlets. A total of 154 samples were obtained from 93 farms. They were analysed for lead, zinc, cadmium, copper and arsenic. Samples showing high lead and cadmium were re-sampled for repeat analysis.

All data were analysed using statistical and geostatistical techniques.

.8 RESULTS AND DISCUSSION

.8.1 Exploratory investigation

This investigation was performed principally to develop site-specific techniques for sampling and analysis.

.8.1.1 Soils

The results served to confirm that the average agricultural soil in the surveyed area had significantly elevated lead, zinc, and cadmium content that allowed for the possibility of at least some impact on crop and animal (Table 4-2). As expected, concentrations of lead, zinc, cadmium, and arsenic from the Gortmore TMF were very high compared with most agricultural soils (Table 4-1).

Table 4-2: Exploratory investigation: mean heavy metal concentrations (mg/kg) in agricultural soils and Gortmore TMF.

	Lead	Zinc	Copper	Cadmium	Arsenic
Agricultural soils (29)*	1136	836	46.2	2.6	35
Gortmore TMF (5)*	8154	7872	150.3	24.8	543

*No. of samples.

.8.1.2 Herbage

On the other hand, herbage concentrations of heavy metals were such as to give rise to much less concern (Table 4-3).

Table 4-3: Exploratory investigation: mean heavy metal concentrations (mg/kg) for herbage from agricultural sites, Gortmore TMF, and comparative values from non-polluted herbage

	Lead	Zinc	Copper	Cadmium	Arsenic
Agricultural sites (29)*	10.7	84.6	7.9	0.45	0.26
Gortmore TMF (4)*	15.9	127.2	7.1	0.81	0.94
Comparative values[1]	0.6	40.3	10.1	0.16	-

*No. of samples.

[1] McGrath *et al*., 1997 for herbages (45) from 21 farms in West Limerick

Regression analyses indicated that herbage lead, cadmium, copper, and arsenic did increase with soil heavy metal concentrations but relationships were poor. Uptake of these metals into plants is limited in various ways. Thus, the presence of high lead on herbage is indicative of contamination by soil, sediment, or dust. On the other hand, the relationship between herbage and soil zinc was highly significant, indicating uptake within the plant rather than on the plant.

Herbage samples from the tailings pond consisted largely of *Agrostis*, *Poa*, and *Holcus* species. Samples from farmland also contained a high proportion of these species. Only 10 contained more than 5% *Lolium sps* although three of these had more than 50% *Lolium sps.* Productive pastures are generally *Lolium sps* dominant.

.8.2 Extensive investigation

.8.2.1 Soils

The survey area encompassed five Gortmore TMF sampling sites and 218 others. Of these, 213 were broadly involved in grassland agriculture and yielded a herbage sample; the remaining samples were from mining sites and are not included in the summary. Many of the agricultural samples had very high concentrations of lead and also of other metals (Table 4-4).

Table 4-4: Extensive investigation: mean heavy metal concentrations (mg/kg) in agricultural soils and Gortmore TMF.

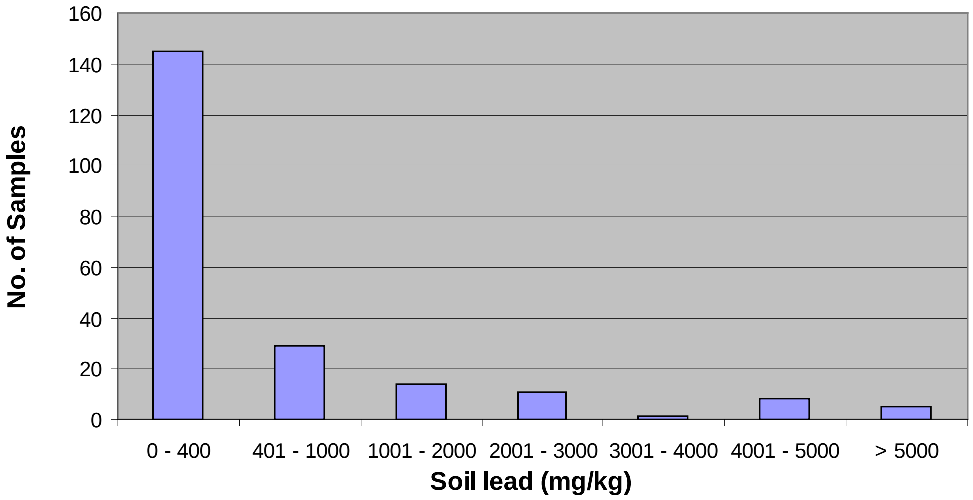
Soils	Lead	Zinc	Copper	Cadmium	Arsenic
Agricultural (213)*	780	365	24.5	1.11	21.9
Gortmore TMF (5)*	11694	7046	395.6	20.21	463.5

*No. of samples.

About one fifth of all soil samples had lead values of 1,000 mg/kg or greater. Soils enriched in lead were also enriched in zinc. High soil zinc concentrations (approximately 1,000 mg/kg) are known to affect plant growth, including pasture establishment, and to inhibit copper absorption by animals.

Soil cadmium concentrations were elevated (> 1 mg/kg) over an extensive area. This raises concern about the accumulation of the metal in both vegetables and animal liver and kidney. Soil arsenic concentrations were not exceptionally high in the agricultural areas.

Figure 4-3: Frequency distribution of lead concentrations (mg/kg) in Silvermines soils (agricultural)



.8.2.2 *Geographic distribution of heavy metals in soils*

Heavy metal (lead, zinc, cadmium, copper and arsenic) distributions in soils of the area were mapped using geographic information systems. To assist in the interpretation of results, soil pH was similarly mapped (Map 11).

Mostly, heavy metal accumulation was associated with either (a) the Gortmore TMF (b) the Shallee area and (c) the Silvermine river and subsequently the Kilmastulla river into which it flows. This pattern of enrichment was best illustrated by lead (Map 12). It must, however, be borne in mind that the map shows predictive data based on sampling locations separated by 400 m. It was reassuring on the five occasions that additional sample(s) were taken from within areas that showed high lead concentrations on mapping, high concentrations were confirmed. Nevertheless, because of the interpolative nature of the technique, areas with very high metal may cast a short shadow outside their boundaries as shown by comparing Map 12 which includes data for Gortmore TMF with Map 13 which omits them. Approximately one third of the mapped area (Map 12) showed concentrations exceeding 1,000 mg/kg.

Distribution patterns for the other metals, zinc (Map 14) and cadmium (Map 15) were similar to that for lead in Map 12 except that the southernmost areas appeared to be more depleted of zinc and cadmium. This was attributed to the acidity (or low pH) of the soil in the southern area as acidity is known to promote leaching of these two metals.

Copper (Map 16) and arsenic (Map 17) again follow the same pattern as lead. However, outside Gortmore TMF, copper and arsenic concentrations were not notably elevated compared with unpolluted areas elsewhere[2].

.8.2.3 *Soil fertility and the impact of lead*

Both acidity, which is corrected by application of calcium carbonate or lime (Table 4-5), and phosphorus deficiency (Table 4-6), were more pronounced than normal. The effects of this may be much more profound than simply limiting the growth of grass. Firstly, phosphate is known to assist in the formation, of more inactive forms of lead in soil[11] thus reducing bioavailability. Secondly, increasing phosphate and calcium in soil will promote uptakes of these nutrients by herbage. Increased concentrations of both calcium and of phosphate in feed are known to reduce the availability of lead to the animal[12,13]. This nutritive effect is likely to be further aggravated by the high proportion of poorer grasses in pastures (*see* 4.8.1.2) as these tend to have lower nutrient concentrations than do productive species. The fertility status of potassium was very similar to normal for soils of Co. Tipperary.

Table 4-5: The percentage distribution of the estimated lime requirements for Silvermine soils and soils of Co. Tipperary.

Lime Requirement (t/ha)	0	0.1 – 5.0	5.1 – 10.0	10+
Silvermines Farms	3	19	25	53
Co. Tipperary[14]	13	32	35	20

Table 4-6: The percentage distribution of the soil phosphorus test values for Silvermine soils and soils of Co. Tipperary.

Soil Test Phosphorus levels (mg/l)	0 – 3.0	3.1 – 6.0	6.1 – 10.0	10+
Silvermines Farms	41	41	14	4
Co. Tipperary[14]	18	35	24	23

.8.2.4 *Lead in Silvermines school play area*

Following evidence from additional analyses, it emerged that the Silvermines school play area had elevated lead and zinc. Thirty one soil samples (0 - 10 cm depth) were taken on a 18 m (North-South) x 20 m (East-West) grid from this enclosed area. These samples were analysed for lead, zinc, cadmium and copper. The results are shown in Map 18.

The pattern for lead was complex with the highest concentrations on the non-tended, westernmost, or left side of the field as viewed from the school. Amounts must give immediate cause for concern, particularly as they relate to a children's play area. This concern is based purely on the magnitude of soil lead concentrations (ranging from 2,301 mg/kg to 37,850 mg/kg) and on the fact that they are greatly in excess of values above which, for many countries, action is recommended[15].

The pattern of concentration for zinc was somewhat similar to that for lead, but with an unrelated major accumulation in the south eastern corner. Cadmium as expected reflected zinc. Copper values were markedly elevated at the mid-section of the western side (the non-tended area).

.8.2.5 *Herbage*

Herbage samples, (115 agricultural and four from Gortmore TMF) from an area West of Kilnacranna to Silvermines, and from 2 km north of the roadway to 400 m South were analysed. The mean herbage lead value was 8.5 mg/kg (Table 4-7). This was lower than the mean value (15.4 mg/kg) recorded over a three-year period for herbage at the Tara mines TMF in Co. Meath where sheep were grazed with no ill effects[16].

Table 4-7: Extensive investigation: mean heavy metal concentrations (mg/kg) for herbage from agricultural sites, Gortmore TMF and comparative values from non-polluted herbage.

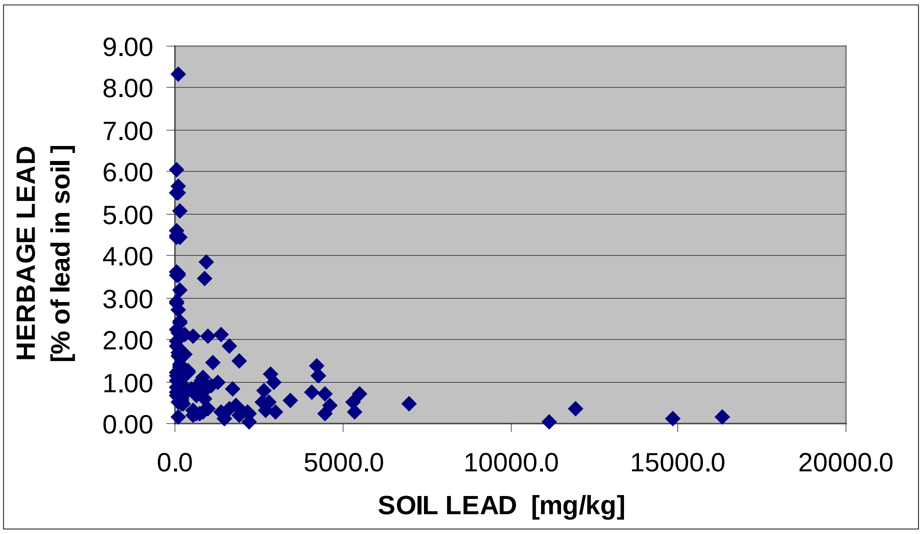
	Lead	Zinc	Copper	Cadmium
Agricultural sites (115)	8.5	93.3	10.9	0.43
Gortmore TMF (4)	29.2	190.6	8.2	1.03
Comparative values[1]	0.6	40.3	10.1	0.16

[1] McGrath et al, 1997 for herbages (45) from 21 farms in West Limerick

Herbage lead is known to arise from physical contamination of the plant surface by soil. The ratio of herbage lead to soil lead should therefore give an indication of the extent to which herbage is contaminated by soil. This value was found to be less than 2% for most herbage in this investigation (Figure 4-4). This was smaller than expected[17]. It could therefore be misleading to equate high lead animal intakes with high soil lead concentrations.

Herbage lead values contrast with those reported for some herbage samples from the same area examined in 1985 and with those reported for the West of Ireland[9]. Both of these reports clearly identified surface contamination of herbage by dust-blow. Consideration of lead concentrations in herbage samples taken North of the Gortmore TMF, where soil lead concentrations were low, indicated no significant effect from dust blow.

Figure 4-4: The extent of herbage contamination with increasing lead in soils.



Mean herbage zinc, copper and cadmium concentrations were similar to those from the exploratory investigation (Table 4-8).

As with soils, mapping of herbage lead (Map 19) showed some interesting features. Highest concentrations tended to occur in very close proximity to a number of waterways including sections of the Yellow river. It is not clear whether this indicates any ongoing contribution from the waterway other than an inclination to wetness which increases the tendency for grass to become contaminated with soil by grazing animals.

.8.2.6 Silage and hay

Silage and hay samples were taken from 54 farms. The range of values for lead and other metals was not unlike those for the herbage studies (Table 4-3 and Table 4-8) with a maximum of 47 mg/kg of lead in fodder. About a quarter of farms had silage, or hay with lead content exceeding 20 mg/kg. Metal concentrations were similar for silage and hay with mean lead concentrations of 10.3 and 11.5 mg/kg, respectively.

Table 4-8: Mean heavy metal content (mg/kg) of silage and hay samples

	Lead	Zinc	Copper	Cadmium
Silage (51)*	10.3	81.1	14.6	0.36
Hay (23)*	11.5	86.8	6.4	0.36

*No. of samples.

Concentrations of lead recorded in the present survey are considered to be below the concentrations that are associated with lead toxicity in animals[12]. However, it should be noted that significant contamination of hay and silage with lead from soil/dust could have a potential for causing lead toxicity[18].

.8.2.7 Water

The standards set in the Drinking Water Regulation (SI 81 of 1988)[19] for lead and cadmium were exceeded in five and three instances, respectively, from a total of 154 water samples analysed. Water contaminated in this way was surface water and mostly from the catchment area of the Yellow River. Repeat analyses proved positive in all instances.

Lead and cadmium in water values may rise during the winter period following oxidative changes occurring over the summer months[20]. Nevertheless, on qualitative grounds, it is difficult to see farm water in this area ever presenting a health risk to animals.

.8.2.8 Recent outbreak on Farm B

Following the deaths of three calves on a farm in late April 2000 (Farm B – *see* Glossary), samples of soil (5), herbage (5), and stream sediment (4) were analysed. Lead was elevated in soil (4,600 –8,005 mg/kg; mean 5,827 mg/kg), herbage(52-188 mg/kg; mean 109 mg/kg), and sediment (6,970-15,945 mg/kg; mean 10,655mg/kg).

Extraction trials showed that lead in sediments was largely solubilised (50% or greater) at pH values below 2.0 but was much less soluble at values in excess of 3.0. Similar results were obtained on soils from the area. It is believed that that the lead concentrations in the soil or sediment samples were sufficiently high, and sufficiently bioavailable, to account for the animal deaths - although other contributory sources are also possible.

.9 CONCLUSIONS

- The extent to which soils of the Silvermines areas contain excessive concentrations of heavy metals, principally lead and zinc, but also cadmium, copper and arsenic has been quantified.
- The quantity of soil lead in about one third of the investigated area indicated a potential risk to grazing animals.
- The quantity of soil lead in the Silvermines school yard gives immediate cause for concern.
- Phosphorus concentrations are low and lime requirements are high for the agricultural soils surveyed compared with the average for Tipperary and nationally.
- The quantity of lead on or in herbage samples indicated no obvious threat to animals.
- Silage and hay samples had lead concentrations similar to grazed herbage and again suggest no obvious threat to animals.
- Drinking water that is available to animals does not appear to be a major provider of lead; only five farm supplies had mildly elevated lead concentrations that exceeded the drinking water standards for humans.
- No significant indication of lead depositions on herbage from dust blow arose during the sampling period.
- Elevated levels of soil cadmium and arsenic were noted particularly in the Gortmore TMF.

.10 RECOMMENDATIONS

- Herdowners should have soil analysed to establish nutrient status and lime requirement. Lime soil to pH 6.5 if necessary. Use adequate phosphate. Apply adequate nitrogen to maintain dense/healthy swards.
- Herdowners should refer to individual farm maps to determine the lead status of their soils.
- Herdowners should ensure that soil is disturbed as little as possible. This means the avoidance of poaching by animals and of damage to sward by machinery.
- Animals should not be allowed to ingest herbage heavily contaminated by soil - whether this material arises as a consequence of poaching, flooding or by wind erosion from tailings pond areas.
- If it is considered necessary to reseed, a part of the area should be tested to ensure that re-growth does occur. Late flowering, preferably diploid ryegrass varieties, should be used to ensure a dense sward.
- Drain sediments should not be spread on pastures.
- The elevated cadmium in soil should be noted in relation to levels of this metal in locally grown vegetables and in animal kidney and liver

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Chapter 5

Human Health Investigation

.1 INTRODUCTION

The Mid-Western Health Board (MWHB) component of this investigation focused on the possible effects of lead on human health. This study aimed to ascertain whether there was evidence of lead toxicity in the population of the area and to recommend appropriate action.

Lead toxicity results from inhalation or ingestion of lead and rarely by skin exposure. Acceptable blood lead concentrations in humans have dropped considerably in recent decades.

This study's methods included:

- the measurement of lead concentrations in whole blood samples from the population;
- the assessment of the general health of the population through a questionnaire-based survey.

The emphasis of the blood-testing was on testing of children, particularly toddlers who are most sensitive to lead toxicity.

.2 METHODOLOGY

The population of the four district electoral divisions (DEDs) in the study area constituted the sampling frame for this study. They were Burgesbeg, Carrigatogher, Lackagh/Greenhall & Kilmore. Using data from the 1996 census the number of residents in the area was calculated at approximately 1,852.

- The residents of all of the farms which fell within the area of investigation were offered screening. There were approximately 85 distinct farms identified in this area.
- Screening was also offered to *all pre-school children* and *primary school pupils* resident in the four DEDs. A letter was sent to parents of all children identified in the area to invite them to have their child or children screened in the clinic or in their school. The screening team offered to visit individual houses for screening purposes if this was more acceptable to the parents.
- A self-selected sample of the remainder of the population of the four DEDs was also screened. The screening programme was widely publicised in local newspapers, at a public meeting held in Silvermines Community Centre and by local community groups and clergy. All those who requested screening were screened.

A screening clinic and drop-in centre was established in Silvermines Community Centre on 6th September, 1999. The purpose of this clinic was to allow locals to attend for screening at a time that was convenient for them and to provide information and advice regarding lead and its relationship with health. This clinic was also open on three Saturday mornings to accommodate those who were unable to attend during the week due to work or other commitments.

The screening test consisted of a venous blood lead measurement and the completion of a questionnaire. Each study participant, or a parent or guardian in the case of a minor, was asked to sign a consent form prior to blood testing. The blood lead estimation was carried out in the Trace Element Laboratory, University Hospital of Wales, Cardiff, an accredited specialist trace metal laboratory.

The results of the blood tests, where within normal limits, were posted to study participants, or their parents in the case of children. Borderline or elevated results were followed up by a visit to the relevant house by a health professional, by an explanation of how the results should be interpreted, and by re-screening for diagnostic purposes.

In accordance with international guidelines, blood lead concentrations of less than 10 µg/dl were deemed to be normal. Those with 'borderline' blood lead concentrations of 10-14 µg/dl were offered re-screening for diagnostic purposes and lead education was provided for the family in the form of health information leaflets and general advice from health care professionals. Similarly, those with elevated blood lead concentrations of 15-19 µg/dl were re-tested and advice was provided. If the lead concentrations remained at this level after three months, referral for clinical management was recommended. Those with higher blood lead concentrations were referred for clinical management (Table 5-1).

Table 5-1: Recommended follow up services (adapted from CDC 'Screening young children for lead poisoning' 1997)

Blood Lead Concentrations µg/dl	Action
<10	No action necessary.
10-14	Follow-up testing. Family lead education.
15-19	Follow-up testing. Family lead education. If blood lead concentration persists or worsens proceed to next stage.
>20	Refer for clinical management. Commence environmental investigation.

Separate questionnaires were designed for adults and children. They covered such areas as demographic details (including environmental details) and exposure history (length of time resident in the area, sources of water and milk and whether a child is a thumb-sucker or eats soil etc.). A section on past medical history and a symptom checklist were also included. All study participants aged 15 and over were also asked to complete an SF-36 questionnaire which is a validated general health questionnaire used internationally.

Two health information leaflets (see Appendix 5.1) were produced during the course of this investigation. The first, which was entitled '*Lead and Health*', provided information on what lead is, how it enters the body, how raised concentrations can be detected and treated, and how individuals can protect themselves against lead poisoning. The second leaflet which was entitled '*Lead and Health - how to interpret your blood test results*' was distributed to those with borderline or elevated concentrations. This leaflet explained the significance of a borderline or elevated result and provided advice on how to prevent lead poisoning.

.3 RESULTS

.3.1 Blood testing

The response to the blood-testing component of the study was very satisfactory and local participation was high. Six hundred and eighty three blood samples were analysed for lead during the course of this study. Map 20 shows the area of residence of the people from whom blood samples were taken.

The overall age and sex breakdown of those screened is shown in Table 5-2 and Table 5-3.

Table 5-2: Age breakdown of population groups screened.

Age Group	Number	Percentage
Pre-school	84	12.3
Primary school	258	37.8
Adults	341	49.9
Total	683	100.0

Table 5-3: Sex breakdown of total population screened.

Sex	Number	Percentage
Male	338	49.5
Female	345	50.5
Total	683	100.0

The results of specific subgroups of the screened population are presented below.

.3.1.1 Pre-school children

Eighty four pre-school children had their blood lead concentrations measured. This represented 62% of the total number of pre-school children identified in the four DEDs of the study area. The age and sex breakdown of those tested is outlined in Table 5-4 and Table 5-5.

Table 5-4: Age breakdown of pre-school children tested

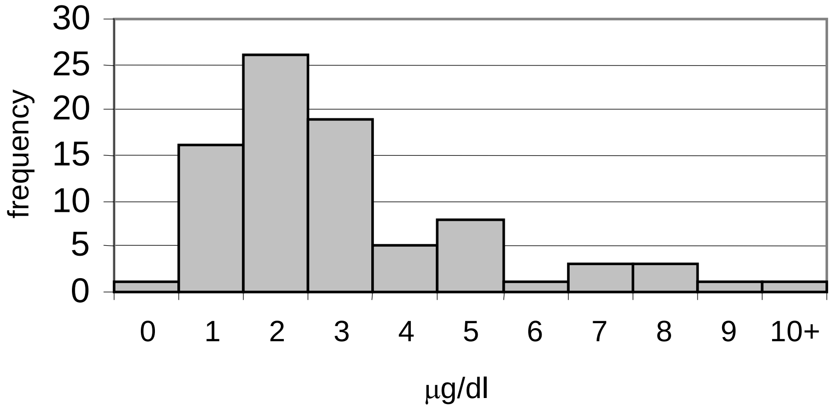
Age Group	**Number**	**Percentage**
<1	14	16.7
1-2	13	15.4
2-3	25	29.8
3-4	26	31.0
4-5	6	7.1
Total	84	100.0

Table 5-5: Sex breakdown of pre-school children tested

Sex	**Number**	**Percentage**
Male	49	58.3
Female	35	41.7
Total	84	100.0

The distribution of blood lead concentrations in pre-school children is shown in Figure 5-1. The average (geometric mean) blood lead concentration was 3.2 μg/dl.

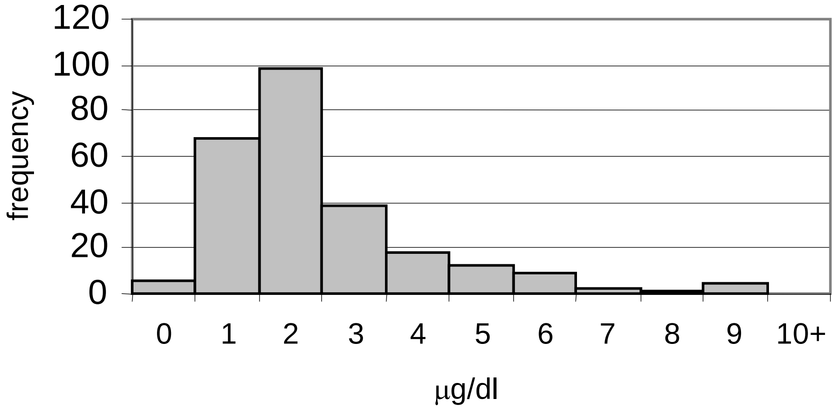
Figure 5-1: Blood lead concentrations in pre-school children in μg/dl (n=84; average=3.2 μg/dl)



.3.1.2 Primary school children

Two hundred and fifty eight primary school children had their blood lead concentrations measured. This represented 85% of the total primary school going population in the five schools targeted in the study area. The age and sex breakdown of those tested is outlined in Appendix 5.2. The distribution of blood lead concentrations in school children is shown in Figure 5-2. The average (geometric mean) blood lead concentration was 2.5 μg/dl. The mean blood lead concentration was higher for children attending the Silvermines school (3.4 μg/dl).

Figure 5-2: **Blood lead concentrations in schoolchildren in μg/dl (n=258; average=2.5 μg/dl).**

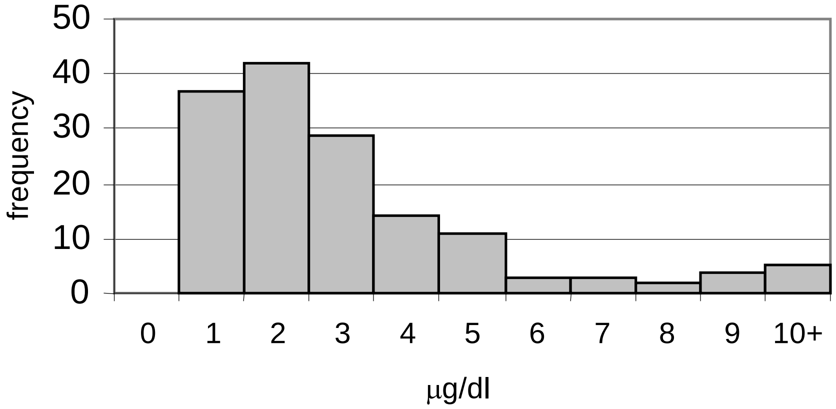


.3.1.3 Farms[*]

One hundred and fifty residents from the 85 farm households identified in the area of investigation had their blood lead concentrations measured. This included one or more participants from 55 farms. The age and sex breakdown of those tested is shown in Appendix 5.2.

The distribution of blood lead concentrations in farm residents is shown in Figure 5-3. The average (geometric mean) blood lead concentration was 3.0 μg/dl.

Figure 5-3: Blood lead concentrations in farm residents in μg/dl (n=150; average=3.0 μg/dl).



.3.1.4 Adults

Three hundred and forty one adult residents of the four DEDs selected had their blood lead concentrations measured. This represented approximately one quarter of the adult population of the area using 1996 census data. This group included all those aged thirteen and over ('adults'). The age and sex breakdowns of those tested are outlined below in Appendix 5.2.

The distribution of blood lead concentrations in adults is shown in Figure 5-4. The average (geometric mean) lead concentration was 2.7 μg/dl.

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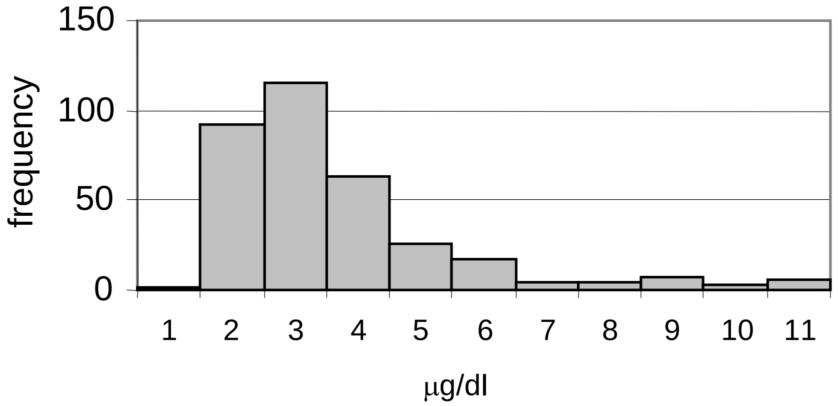
[*] The results of the adult, pre-school, and school going farm residents are also included in sections (a), (b) and (d)

Figure 5-4: Blood lead concentrations in adults in µg/dl (n=341; average=2.7 µg/dl).



.3.2 Questionnaires

.3.2.1 Adult questionnaire

This questionnaire was completed by 275 adults aged 18 and over. The mean length of time that respondents had lived in the area was 26.7 years. Over one quarter of respondents (74; 26.9%) use private water supplies and a further third (90; 32.7%) are on group water schemes. One hundred and five respondents live on a farm. Seventy-seven (28.0%) respondents grow fruit and vegetables at home for their own consumption.

Mean lead concentrations were statistically significantly higher in males than in females (3.9 µg/dl versus 2.6 µg/dl). Forty-two respondents (15.3%) had worked in the mines in the past. The mean lead concentration in this group (5.0µg/dl) was statistically significantly higher than the mean concentration in those who had never worked in the mines (2.8µg/dl).

Fifty two (18.9%) of the adults surveyed reported suffering from health problems in the month preceding the survey and 75 (27.3%) in the year preceding the survey. Frequencies were calculated for specific medical conditions and symptoms. As there was no control population, these frequencies were compared to those of a control population used in a 1996 UK study of gardens contaminated by heavy metals[1]. There were no major differences detected in health status between the two populations.

The mean scores for the SF-36 questionnaires amongst the adult population were comparable to those obtained in a UK national survey[2]. This would suggest that the general health of the population of the study area is similar to the general health of the population in the UK.

.3.2.2 Child questionnaire

Three hundred and sixty five questionnaires were completed by or on behalf of those aged under 18. The mean age of the respondents was 7.7 years. The majority of respondents were primary school children. Regarding risk factors for lead toxicity, 18 children (4.9%) from the study area eat soil and 53 (14.5%) suck their thumbs. Three hundred and thirty three (91.2%) respondents play in the garden at home.

The mean lead concentrations were compared in groups with and without the various postulated risk factors using analysis of variance. The mean lead concentration in those who eat soil was 4.8µg/dl compared to 3.0µg/dl in those who do not. This difference was not statistically significant. This may be due to the small sample size in the former group (n=18) but it may be an important result. There was no statistically significant difference in blood lead concentration in thumb suckers when compared to those who do not suck their thumbs (3.3µg/dl versus 3.1µg/dl). Similarly the difference in lead concentrations between those who do and do not drink unpasteurised milk was not statistically significant.

Forty seven (12.9%) of the children surveyed had reported health problems in the month preceding the survey and 97 (26.6%) in the year preceding the survey. Seventy six respondents reported having been diagnosed by a doctor as having a medical problem.

.4 DISCUSSION

Out of a total of 683 screening blood samples taken, only seven samples exceeded the CDC acceptable limit of 10 μg/dl. Of these, four were classed as borderline and the other three were elevated. This group consisted of five males and two females. One was a pre-school child and six were adults. Five were residents of farms in the study area.

The average value of blood lead amongst the population screened was 2.7 μg/dl. The average concentration obtained amongst a sample of 46 Irish adults screened prior to entry into military service in 1994 was 4.4 μg/dl[3]. Average concentrations obtained from another mining area in Ireland in 1977 were 8 μg/dl for children and 7 μg/dl for adults prior to the commencement of mining[4]. It is difficult to directly compare these averages with current averages as environmental concentrations of lead may have been higher at that time due to factors such as the widespread use of leaded petrol. The acceptable concentration of lead in human blood at that time was up to 25 μg/dl.

The results of the questionnaires would suggest that the health of the population of the study area is similar to that of the general population using a number of objective measures including: SF-36 scores and the prevalence of certain chronic conditions and symptoms when compared to control populations from other studies. One limitation of this study was the absence of an Irish control group which would allow direct comparisons to be made between the health status of the study population and that of a control group.

In summary, although high concentrations of lead have been found in the environment in certain parts of the study area, including the play area in Silvermines primary school, the investigation suggests that these concentrations are not being transferred to the human population at present. The literature would suggest that lead from mining or tailings does not always cause raised blood lead concentrations similar to those caused by other sources such as smelting. Postulated reasons for this include factors such as particle size and bio-availability.

This study does, however, highlight a number of risk factors for lead poisoning which should be addressed with a view to ensuring that environmental lead does not translate into raised lead concentrations in humans. The elevated soil lead concentrations found in certain parts of the study area are of particular concern.

.5 CONCLUSIONS

Although high concentrations of lead have been found in the environment in certain parts of the study area, the investigation indicates that these concentrations are not being transferred to the human population at present. Residents of the study area can, therefore, be reassured that their blood lead concentrations are generally within the accepted international standards. The high concentration of lead found in the soil taken from the play area in Silvermines village (*see* Section 4.8.2.4) which is an area accessed by children is, however, of particular concern and must be addressed. Access to the adjacent hillside where children currently play and to other areas which are high in lead should also be discouraged until further investigations are carried out (see Section 8.6). Although average blood lead concentrations were higher in children in Silvermines school than in the other schools in the area covered by the health study, these results were still well within acceptable limits. There is also a need for on-going screening of young children in the area and for the use of continued precautionary measures to minimise exposure to lead by the community. A detailed investigation of lead in the residential environment of Silvermines village is also needed.

.6 RECOMMENDATIONS

- The school play area in Silvermines village should be resurfaced immediately. It should then be fenced in to define a safe play area for children.
- Until the areas with high lead concentrations have been rehabilitated, children should be discouraged from accessing these areas.
- A programme of annual blood lead surveillance should be implemented for pre-school and school children in the Silvermines area. The results of this programme which will commence in Autumn, 2000 should be reviewed after two to three years of testing.
- Internal and external environmental sampling consisting of dust sampling in houses and soil sampling in gardens should be carried out in Silvermines village on a once off basis in Autumn, 2000.
- Steps must be taken to enhance and maintain public awareness of the presence and influence of lead in the Silvermines area.

- The active involvement and assistance of the local community, and of community based organisations, should be secured in addressing lead exposure and specific prevention strategies through education on:
  - basic hand-washing practices with a special focus on pregnant women and the parents of young families,
  - washing of locally-grown fruit and vegetables for domestic consumption,
  - the importance of adequate dietary intake of calcium, iron and vitamin C,
  - dust minimisation in the home.

.7 REFERENCES

1. **Oxfordshire Health Authority**. Land Contamination In Bertie Place. Oxfordshire Health Authority Oxford, 1996.

2. **Short Form 36 (SF-36) Health Survey questionnaire: Health Survey for England**, 1996. Vols 1 and 2. Prescott-Clare P, Primatesta P, eds. London: The Stationery Office, 1998.

3.**Loftus, E.F.** Occupational health hazards of inorganic lead in modern military training. Dissertation presented to the Faculty of Occupational Medicine, Royal College of Physicians of Ireland, 1994.

4. **Western Health Board**. Progress report on pilot survey for monitoring population exposure to lead. Prepared for the Health Protection Directorate of the Commission of the European Communities, Brussels, 1997.

Appendix 5.1

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[*App5_1a.doc – page 2 of 2.]*

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Appendix 5.2

Age and sex breakdown of population groups screened.

(a) School children

Table 5-6: Age breakdown of school children tested.

Age Group	Number	Percentage
4-6	73	28.3
7-9	108	41.9
10-12	77	29.8
Total	258	100.0

Table 5-7: Sex breakdown of school children tested.

Sex	Number	Percentage
Male	139	53.9
Female	119	46.1
Total	258	100.0

(b) Farm residents

Table 5-8: Age breakdown of farm residents tested.

Age Group	Number	Percentage
0-4	9	6.0
5-12	21	14.0
13-44	61	40.7
45-64	41	27.3
65+	18	12.0
Total	150	100.0

Table 5-9: Sex breakdown of farm residents tested.

Sex	Number	Percentage
Male	77	51.3
Female	73	48.7
Total	150	100.0

(c) Adults

Table 5-10: Age breakdown of adults tested.

Age Group	Number	Percentage
13-44	207	60.7
45-64	98	28.7
65+	36	10.6
Total	341	100.0

Table 5-11: Sex breakdown of adults tested.

Sex	Number	Percentage
Male	150	44.0
Female	191	56.0
Total	341	100.0

Chapter 6

Assessment Of Drinking Water And Food Produce From Study Area

.1 INTRODUCTION

This chapter summarises the investigations carried out by the Mid-Western Health Board (MWHB) in relation to drinking water and locally-produced fruit and vegetables, and the Department of Agriculture, Food, and Rural Development (DAFRD) in relation to locally-produced milk and meat.

.2 DRINKING WATER, FRUIT AND VEGETABLES

The Environmental Health Department of the MWHB carried out a survey of drinking water for human consumption and fruit and vegetable samples from the identified area of investigation. The sampling locations are indicated in Map 21 and Map 22. The aim of this survey was to assess whether water supplies for human consumption, and fruit and vegetables grown within the area of investigation, are within current statutory limits and, in the context of food safety, fit for human consumption.

.2.1 Background

During the mid-1980's, when dust blows from the TMF at Gortmore occurred, the MWHB undertook a similar study of water, fruit, and vegetables in the area surrounding the TMF. This study was carried out between July 1984 and November 1988. Results of water samples taken at that time indicated that all water supplies were satisfactory and within normal ranges for lead concentrations.

Following the first dust blow in June, 1984, vegetable samples were taken in the Capparoe area as the prevailing winds were south-westerly. All results at that time were satisfactory.

In February, 1985, more severe dust blows took place in the Gortmore/Castlecranna areas during strong easterly winds. Results of vegetable sampling revealed high concentrations of lead contamination at that time.

Sampling continued in these areas until November, 1988. A pattern emerged of elevated lead readings in vegetables during dust blows - with a marked decrease at other times to concentrations well within statutory limits.

Following a programme of rehabilitation of the TMF at the time, the risk of further dust blows was reduced and sampling ceased when results, over a period of time, were shown to be within statutory limits.

.2.2 Methodology

For the purposes of the present study, samples of drinking water (for human consumption) and fruit and vegetables were obtained between mid-June and mid-October, 1999 from the farms identified within the area of investigation. Samples were also obtained from those households which had presented for blood testing at the Silvermines clinic. Such households were selected so that lead in water, fruit and vegetables could be compared to blood lead concentration results obtained through population screening.

All samples were tested for the presence and concentrations of lead cadmium and zinc. Limitations of the study were that:

- Control samples from areas outside of the study area were not taken.
- It was not possible to re-sample fruit and vegetables which had indicated elevated lead and cadmium concentrations due to the time delay in receipt of results. Normal procedure would dictate that re-sampling should be carried out on such samples but this was not possible as fruit and some vegetables were not available during the winter months.

.2.3 Relevant legislation

The following pieces of legislation set standards for permissible concentrations of various metals in food and water.

1. EC Directive 80/778/EEC of 15 July 1980; given effect in Irish Law by the EC (Quality of Water intended for Human Consumption) Regulations 1988, S.I. No. 81 of 1988.

2. Drinking Water Directive 98/83/EC of 25 December, 1998 – Regulations to comply with this Directive must be brought into force by 24 December, 2000.
3. Health (Arsenic and Lead in Food) Regulations 1972, S.I. No. 44 of 1972.
4. EC (Official Control of Foodstuffs) Regulations 1998, S.I. No. 85 of 1998.

.2.4 Results

.2.4.1 *Drinking water*

A total of 74 samples was tested for lead, cadmium and zinc. Water supplies within the study area were predominately from group schemes and private supplies, with only two public supplies available. Of this number, only one supply (group scheme) exceeded the statutory limit of 50 μg/l for lead in drinking water as set down in the 1988 Regulations. It is of note that variations in results from this group scheme were obtained over a period of time, with some results coming within the statutory limit The particular group scheme in question has now been replaced by a new scheme which has been tested and found to comply with all relevant standards.

.2.4.2 *Fruit and Vegetables*

Seventy seven samples were tested for the presence of lead, cadmium and zinc. Two samples of lettuce and one sample of rhubarb exceeded the current statutory limit for lead in foodstuffs of 2 mg/kg. It is of note that all three samples were taken from gardens in Silvermines Village. However, other fruit and vegetables (cabbages, apples, onions) sampled from the same locations on the same days recorded lead concentrations well within statutory limits. Hence, because of such variations, there is a need for further sampling at different times of the year. The remaining samples were deemed to be satisfactory. Presently, there is no statutory limit for cadmium in foodstuffs.

.2.5 Conclusions

- Drinking water for human consumption from within the study area is, on the whole, compliant with the Drinking Water Regulations for concentrations of lead and cadmium. Only one supply (which has since been replaced as planned prior to the commencement of this study) showed elevated concentrations of lead. It is of note that variations in lead concentrations were obtained in this supply.
- Less than 4% of fruit and vegetable samples were found to be in excess of the statutory limit for lead; the remainder of samples were satisfactory. Before firm conclusions can be drawn from such results, further sampling will be necessary as outlined below. Studies have shown that the mean lead content for vegetables is greater in spring sampling than in winter sampling. This is consistent with literature reports that plants accumulate a higher level of lead in the winter months[1].
- It is of note that all fruit and vegetable samples which contained lead concentrations in excess of the statutory limit were grown in Silvermines Village. This has previously been identified as an area containing lead-enriched soils.

.2.6 Recommendations

- Monitoring of local drinking water should be continued to ensure compliance with relevant standards.
- The following steps should be taken with all locally-grown fruit and vegetables in order to reduce dietary exposure to lead:
    1. Wash all fruit and vegetables thoroughly in running water that is of drinking quality before consumption.
    2. Peel potatoes prior to cooking and consumption.
    3. The outer leaves of leafy vegetables should be removed prior to washing and consumption.
- A further programme of fruit and vegetable sampling should be undertaken. The duration of time over which sampling will continue will depend on the results.

.2.7 References

1. **Lead in Food**: Progress Report (MAFF), 1989.

.2.8 Acknowledgements

Public Analyst Laboratory (water and food sections), University College Hospital, Galway.

.3 MILK AND MEAT

The DAFRD undertook a survey of lead concentrations in bulk-milk collected from dairy farms in the Silvermines area. In addition, samples of muscle, liver and kidney from cattle sent directly for slaughter were analysed for lead content.

.3.1 Scope of the investigation

Twenty eight dairy herds were identified in the Silvermines area. Milk samples for lead analysis were collected from bulk tanks on the 26 that were in milk production at the time of the investigation.

Samples of liver, kidney and muscle were also collected for lead analysis from animals sent for slaughter from the area. Initially, farmers were requested to inform the District Veterinary Office when cattle were being sent for slaughter. Subsequently, herds in the area were identified by herd number on the Cattle Movement Monitoring System (CMMS). This system alerts DAFRD personnel at beef plants nationally when animals are sent directly from the herd for slaughter. Also on CMMS, the animals from five herds were identified by individual tag numbers.

Table 6-1: Maximum permitted lead concentrations in milk, milk products, meat, liver and kidney for human consumption[1].

Food	Limit (mg/kg)[1]
Milk, milk products	1.0
Meat, liver, kidney	2.0

[1] S.I. No. 44 of 1972.

.3.2 Investigation methodology

Liver, kidney and muscle were analysed using standard methodology at the Central Meat Control Laboratory, Abbotstown and the Veterinary Laboratories Agency, Shrewsbury, England. Milk samples were analysed at the Veterinary Laboratories Agency, Shrewsbury, England.

.3.3 Results

.3.3.1 Milk analysis results

Bulk milk samples for lead analysis were collected from 26 dairy herds in August, 1999. Concentrations ranged from 0 to 0.027 mg/kg with an overall mean of 0.007 mg/kg (Table 6-2). All samples had concentrations below 0.030 mg/kg which is well below the maximum permitted for human consumption i.e. 1.0 mg/kg. Two herds, which had values between 0.020 and 0.030 mg/kg, were re-sampled in October. Values then were below 0.010 mg/kg in both cases.

Table 6-2: Distribution of bulk-milk lead concentrations (mg/kg) from 26 dairy herds (two herds were sampled on three occasions).

Lead concentration	Number samples
0 – 0.01	23
0.01 – 0.02	5
0.02 – 0.03	2*

*First sampling in Aug-99

.3.3.2 *Tissue analysis results*

Up to the end of March, 2000, tissue samples had been collected and analysed from 276 cattle presented for slaughter and originating on 22 farms in the area of investigation. These represent approximately 4% of the cattle and 25% of the farms in the area. Summary results of lead analysis are given in Table 6-3.

Table 6-3: Lead concentrations (mg/kg) in tissues of animals from the area of investigation.

Tissue	Average	Range	No. samples
Kidney	0.47	< 0.01[1] – 9.95	276
Liver	0.25	< 0.01 - 3.35	265
Muscle	0.05	< 0.01 - 0.91	265

[1] Detection limit

The percentage distribution of tissue lead concentrations is given in Table 6-4. All 265 muscle samples were within the range 0 – 2 mg/kg. Liver or kidney from 11 of the 276 animals sampled, originating from six farms, had lead concentrations greater than 2 mg/kg. Five were from one farm.

Table 6-4: Percentage distribution of tissue lead concentrations.

Concentration (mg/kg)	Kidney	Liver	Muscle
0 – 2	96%	98%	100%
2 – 5	2%	2%	0%
5 – 10	2%	0%	0%

.3.4 *Conclusions*

.3.4.1 *Milk*

Lead concentrations in bulk milk samples from dairy farms in the Silvermines area were all within the maximum legally permitted limit for human consumption. On the basis of these results, there are no public health implications with regard to lead concentrations in milk from the area.

.3.4.2 *Meat - muscle*

Lead concentrations in all 265 muscle samples tested were within the permitted limits for human consumption.

.3.4.3 *Meat - liver and kidney*

Over 95% of 276 animals sampled had liver and kidney lead concentrations within the permitted range for human consumption (0 – 2 mg/kg). Eleven animals from six farms had kidney and/or liver lead concentrations above 2 mg/kg. Additional data is required for the unsampled farms. It appears that most of these do not finish cattle. The present data indicates that animals with raised kidney or liver lead concentrations are confined to a small number of farms.

.3.5 *Recommendations*

.3.5.1 *Milk*

- Any dairy herds not in production during the 1999 round of milk sampling should be sampled when production resumes.

.3.5.2 *Meat - liver and kidney*

Public health recommendations

- Liver or kidney with lead or cadmium concentrations above those permitted for human consumption must not knowingly be placed on the market. Livers and kidneys from herds that have shown such concentrations must be excluded from the food chain unless and until it can be shown at the 95% confidence level that the concentrations of these metals are below the permitted limit.

General Recommendations for farms in the Silvermines area

- Monitoring of lead concentrations in the liver and kidneys of all slaughtered cattle from the area – using the CMMS system for animal identification or another effective system- should continue until the end of 2000 when the need for further sampling will be reviewed.

- The need for a re-introduction of tissue monitoring beyond 2000 should be considered in the light of results obtained and in the event of future incidents of excess lead contamination in the area, e.g. flooding or dust blows.

- Cadmium concentrations should be monitored in tissues (kidney) of animals from farms where high soil cadmium concentrations have been detected.

Specific Recommendations for individual farms with concentrations of lead in liver/kidney of cattle above those permitted for human consumption.

- A management system designed to minimise lead intake by food animals, should be drawn up for each farm by DAFRD in consultation with Teagasc. The CMMS must be used to identify each animal.

- Assessment of the effectiveness of the management system should be based on tissue sampling and analysis.

The need for continued sampling of these farms should be reviewed at the end of 2000.

Chapter 7

Animal Health Investigations

.1 INTRODUCTION

The animal health aspects of the Silvermines investigation were the responsibility of the Veterinary Laboratory Services of the Department of Agriculture, Food, and Rural Development (DAFRD). The objectives of the study were:

- to quantify the uptake of environmental lead by cattle in the area;
- to determine its significance in relation to animal health.

The decision to restrict the investigation to cattle was made on the grounds that cattle are the predominant food-producing animal in the area and are also more susceptible to the toxic effects of lead than sheep.

.1.1 Background

Lead poisoning is the most commonly-reported form of toxicity in cattle in this country[1,2,3]. The majority of episodes involve only one or two animals and the sources can generally be traced to the ingestion of man-made products such as lead batteries and lead-containing paints. Lead poisoning outbreaks arising from environmental sources, on the other hand, are less common and are generally associated with lead mining activities.

Egan & O'Cuill[4] reported cases of abortion in ewes and deaths in cattle and sheep grazing lead-contaminated pastures in the vicinity of an open-cast mine in Co. Galway. The first recorded outbreak of environmental lead poisoning in animals in the Silvermines area occurred in 1969 and involved horses on a farm close to an active lead mine[5]. On this occasion, five horses were affected and four died. Further cases of lead poisoning in the area - generally involving only one or two animals - were suspected or confirmed during the early 1980s.

Little information is available on the incidence of lead poisoning in the Silvermines area between 1985 and 1995. However, a review of specimen throughput for Limerick Regional Veterinary Laboratory (RVL) for the period does not indicate an unusually high incidence of suspect lead poisoning submissions.

Details of all submissions to Limerick RVL from the area for the years 1992 to 1999, and on which tissue lead analysis was performed, are given in Appendix 7.1. At an average rate of less than two per year up to 1999, they do not suggest a widespread problem with clinical lead poisoning. Although lead analysis was carried out on 19 submissions in 1999, the increase can largely be attributed to the increased interest in the condition following the outbreak on Farm A at the beginning of the year (*see* below). Three of the four cases of lead poisoning diagnosed in 1999 related to this farm.

However, it is unlikely that laboratory data on its own can be taken as an accurate reflection of the incidence of lead poisoning cases in the area. Given the characteristic clinical signs of the condition - and particularly in a former lead-mining area - it is reasonable to assume that not all cases would be referred for laboratory investigation. During the course of the present investigation, for example, information was obtained on a number of individual or multiple cases which had not been referred for laboratory investigation. One herdowner (referred to hereafter as Farm B) reported that six calves at grass had been affected in the spring of 1998 – five of which died. None were submitted for laboratory examination. A further outbreak occurred on this farm in April, 2000 (*see* below).

.1.2 Lead poisoning cases in the Silvermines area in 1999/2000

The cases of lead poisoning diagnosed in the first part of 1999, and which lead to the present investigation being initiated, all occurred on a single farm (Farm A). This was the same farm on which several of the reported or confirmed cases had occurred in the early 1980s.

The first case in 1999 was a cow which had shown neurological signs prior to her death in January. Laboratory analysis of kidney tissue revealed a lead concentration of 62 μmol/kg[*] (~13 mg/kg) which is

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[*] Conversion: 1 mg/kg = 4.83 μmol/kg.

consistent with toxicity. Lead poisoning was also diagnosed in two bullocks submitted for post-mortem examination at the end of April, 1999. A third bullock which died at the same time, but which was not submitted for laboratory examination, was reported to have had clinical signs consistent with lead poisoning.

Only one other case of lead poisoning was confirmed by laboratory diagnosis in the area in 1999 (Appendix 7.1).

A further outbreak of lead poisoning occurred on Farm B in April, 2000. The circumstances were similar to those reported for the 1998 outbreak. Four of a group of 19 suckler calves turned out to grass two weeks previously died – two were found dead and two died after exhibiting nervous signs. Lead poisoning was confirmed by analysis of tissue samples from the two which were submitted for laboratory examination. Blood samples subsequently collected from five surviving calves in the group all had lead concentrations consistent with toxicity.

.1.3 Clinical signs and diagnosis of lead poisoning

While the underlying mechanisms for lead toxicity are similar in man and animals, the condition in animals is generally acute in onset and of short duration. Cases are characterised by sudden onset of staggering, bellowing, muscle tremors, and blindness - followed by death in one or two days. Although the severity of signs varies with intake and duration of exposure, chronic neurological disease of the type observed in humans is not a feature of the condition in farm animals.

A presumptive diagnosis of lead poisoning can often be made on the basis of clinical signs together with evidence of exposure to a known source. Table 7-1 lists blood and tissue lead concentrations which can also be used to confirm a diagnosis.

Table 7-1: Interpretation of blood and tissue lead concentrations in cattle.

Sample	Concentration	Interpretation
*Blood (μmol/l)**		
	0 – 1.2	Normal range[6].
	1.2 – 1.7	Elevated but not of clinical significance.
	1.7 – 2.4	May be associated with signs of toxicity.
	> 2.4	Generally associated with signs of toxicity.
Kidney (mg/kg)		
	0 – 2	Normal range[6].
	2 – 5	May be associated with signs of toxicity.
	> 5	Consistent with toxicity.

* 1 μmol/l = 20.70 μg/dl

.1.4 Sources of lead

The majority of cases of lead poisoning in farm animals are due to man-made materials. These include lead batteries, linoleum, and lead-containing paints. Significant outbreaks in cattle in this country have also been associated with contamination of silage by lead batteries accidentally shredded in the harvesting process[9]. Abroad, outbreaks have been reported in cows eating conserved fodder contaminated by lead shot[10] and silage which had been contaminated by a residue of plastic-coated wire burnt on the floor of the clamp[11].

Lead of natural origin is ubiquitous in the environment[7]. Background soil concentrations on grazing land range from about 2 to 200 mg/kg[8]. For farm animals, soil is the main source of environmental lead – either by direct ingestion of soil or as soil-contamination of herbage or conserved fodder. Reported outbreaks of poisoning in farm animals due to lead of geological origin, however, are uncommon. They are generally confined to areas where lead-rich deposits have been brought to the surface by mining and related smelting activities[12,13,14].

An absolute upper limit of safety for soil lead in grazing land has not been determined. Although a UK government committee advising on the restoration of former mining lands for grazing has recommended that soils with lead concentrations above about 1,000 mg/kg are not suitable for continuous grazing[15], practical experience has demonstrated that toxicity can generally be avoided on soils with several times this concentration by the use of routine pasture management practices, e.g. rotational grazing and winter housing. As an extreme example, Butler *et al*[1] reported that acute disease in lambs on soils of up to 19,500 mg/kg lead could be minimised by a combination of local knowledge, fencing and grazing management.

The reasons for such wide variations in the effective toxicity of lead in soil for grazing animals relate to factors affecting the quantity of soil ingested and the availability of lead therein. The former is affected by weather, soil type, and height of grass sward. Animals on wet, poached pastures, for example, will consume relatively high quantities of soil (up to 20% of diet[2]). The latter, i.e. lead availability, is a function of pH (acidity/alkalinity) and the chemical form in which the lead is present. Calves are more susceptible to lead poisoning than older cattle, both owing to their greater propensity to lick or ingest non-food materials, and to the lower pH of their digestive fluids.

.2 SCOPE AND METHODOLOGY OF INVESTIGATION

The geographical extent of the overall investigations is illustrated in Map 2. The animal health investigations comprised a program of blood-sampling of cattle on the farms identified within the area indicated in Map 23 (outlined in red). A questionnaire on animal health and production was also posted to herdowners and further information was collected during farm visits and from private veterinary practitioners in the area. Information collected during the abattoir tissue survey (*see* Section 6.3) was also of value for the animal health investigations.

Herdowners were circulated with details of the proposed investigations and arrangements for blood and milk sampling were made by telephone or house calls. The purpose and scope of the investigation were described at the public meeting held in Silvermines village on 1 September, 1999.

Ninety six farms were identified in the area of investigation. Sixty one herdowners participated in the programme of farm visits and blood-sampling. Nineteen of these had land rented from herdowners with no stock of their own which brought the total number of farms on which cattle were blood-sampled to 80 of the 96 originally identified. Ten farms had no stock. The remaining six herds did not participate for a variety of reasons. Details of milk and tissue sampling are reported elsewhere (*see* Chapter 6). The approximate locations of farms where blood samples were collected are shown in Map 23.

Blood samples were collected from a representative number of cattle on each of the participating farms (i.e. 10% or ten, whichever was greater). Sampling was carried out between July and November, 1999 and almost all animals were on pasture at the time of blood-sampling. Where possible, animals over one year old were selected for sampling as they were likely to have been exposed to environmental concentrations of lead for longer periods than younger stock. Blood samples were analysed by standard techniques at the Central Veterinary Laboratory, Abbotstown.

For the purposes of the animal health studies, the value of 1.2 μmol/l was taken as the upper limit of the normal range for blood lead[6]. Farms with one or more blood samples above this value were selected for further animal and environmental investigations.

Blood samples were also analysed for copper and zinc. This was done to investigate the possibility that elevated environmental concentrations of zinc, often found in areas of lead enrichment, could affect copper uptake. There is evidence that elevated concentrations of zinc in the diet can reduce the bioavailability of copper [18]. Deficiency of the latter can have a significant negative impact on animal health and production.

Information on animal health was obtained *via* the postal questionnaire, private veterinary practitioner interview, and farm visits. The animal health questionnaire was circulated to all identified herdowners in the area in July, 1999. It was re-circulated to non-responding herdowners in October, 1999.

.3 RESULTS

Blood samples were collected from a total of 598 cattle on the first round of farm visits. Details of cattle types sampled are given in Table 7-2.

Table 7-2: Numbers of cattle from which blood samples were collected.

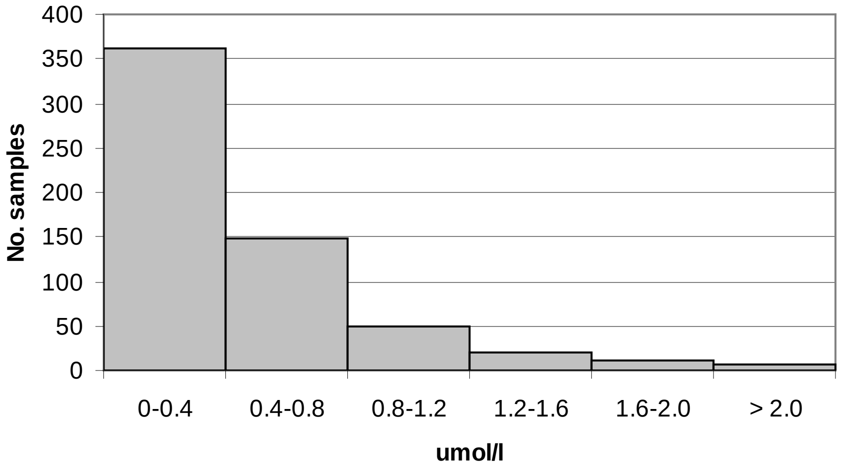
Animal Type	No. Sampled
Cows	387
Bullocks (over 1 yr. Old)	105
Heifers (over 1 yr. Old)	94
Weanlings (cattle under 1 yr. old)	11

Bulls	1
Total	598

.3.1 Blood analysis

The distribution of blood lead concentrations in samples collected from cattle on the first round of farm visits is shown in Figure 7-1. The average (geometric mean) blood lead concentration was 0.31 μmol/l (range 0.06 – 2.55).

Figure 7-1: Overall distribution of blood lead concentrations (μmol/l) in area of investigation.



Five hundred and sixty (93.7%) of the 598 samples had lead concentrations within the normal range of 0 - 1.2 μmol/l. Thirty eight samples, originating from stock on 13 farms, had concentrations above 1.2 μmol/l. Summary results for all farms with above-normal values are given in Appendix 7.2.

Dry stock had significantly higher blood lead concentrations than cows (0.57 μmol/l *vs.* 0.38 μmol/l; $p <$ 0.001). Mean concentrations for cows classified as dairy *vs.* suckler were not significantly different.

There was no evidence of a significant trend in blood lead concentrations with animal age. The mean concentration for cows under four years old was 0.34 μmol/l compared to 0.36 μmol/l for cows four to eight years and 0.35 μmol/l for cows over eight years old.

A high proportion of blood samples (125 of 589) had copper concentrations below the reference range of 9.4 – 24 μmol/l. Nineteen of these were below 3.0 μmol/l. All blood zinc concentrations were within the reference range for cattle of 5 – 25 μmol/l.

.3.2 Tissue analysis results

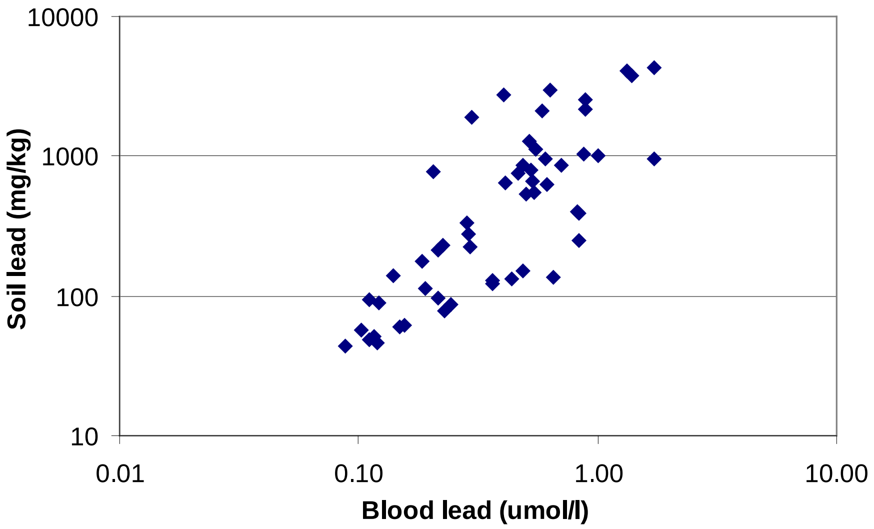
The results of the tissue lead sampling program are given in Chapter 6. Over 95% of the 276 cattle sampled had kidney and liver lead concentrations below 2.0 mg/kg. Eleven animals from six farms had one or more tissue values above 2.0 mg/kg. In the case of four farms, only single samples were involved – two of which were from aged cows. Five of 21 animals from the fourth farm had kidney or liver lead concentrations above 2 mg/kg (range 2.28 – 9.95 mg/kg).

Three of these farms have been re-visited by DAFRD veterinary staff for the purposes of animal health investigations and further blood sample collection. Visual inspection failed to reveal any man-made lead sources to which cattle may have had access. None of the four farms had a history of lead poisoning outbreaks and the animals from which the tissues were collected were reportedly in good health prior to slaughter. The other farms in question will be re-visited during the current grazing season.

.3.3 Relationship between animal and environmental lead concentrations

Comparison of mean blood and soil lead concentrations per farm showed a high degree of correlation between the two, i.e. cattle on farms with high soil lead concentrations also tended to have high blood lead values (log-transformed $r^2=0.63$; $p< 0.001$). This relationship is illustrated in the scatter plot of blood *vs.* soil lead concentrations in Figure 7-2.

Figure 7-2: Relationship between mean farm blood (µmol/l) and soil (mg/kg) lead concentrations (log scale)[1]**.**



[1] Blood and soil data-pairs available for 53 farms.

The relationship between tissue lead concentrations and either blood or soil values was less well-defined. Summary blood and soil results for all farms with above-normal tissue values are given in Appendix 7.2. From these it can be seen that three (farms Q, T and E) of the six farms with raised tissue values had no blood samples with above-normal lead concentrations; soil concentrations on two of these three farms were below 900 mg/kg. A fourth farm (E) which had a large number of raised blood values had only one of 16 tissue values above 2 mg/kg, while a fifth farm (C) had both raised blood and soil concentrations. No blood analysis results were available from the sixth farm (V) as it did not participate in the sampling program.

.3.4 Animal health

Forty nine completed questionnaires were returned from farms with stock. Reported farm sizes ranged from about four to 80 hectares (average 32 hectares). Cow numbers ranged from one to over 100 with an average of 27 per farm. Nineteen farms were classified as dairy, 29 suckler, and one mixed.

Details of reported animal health incidents in 1998 and 1999 are given in Table 7-3. While incidence rates cannot be determined from the supplied data, there is no evidence to suggest that the area had suffered an unusually high incidence of disease. Neither is there any evidence that there has been an unusually high incidence of lead poisoning cases. Only five farms reported suspected lead-poisoning incidents in the two-year period 1998-99 – only one of which involved laboratory-confirmed cases. On three farms, only single cases were involved and the diagnoses were made purely on clinical grounds. The other two reports involved multi-case outbreaks – one of which was confirmed by toxicological analysis (Farm A - *see* page 76).

Table 7-3: Numbers of farms reporting cattle disease outbreaks in 1998 and ’99 (49 questionnaire returns).

Disease	Number farms
Respiratory/enteric disease in calves	11
Salmonellosis (calves/adults)	5
Pining (adults)	3
Redwater (multiple cases)	2
Mastitis	1
Miscellaneous (cows)	3
Lead poisoning	5[1]
No incidents reported	24

[1] Only one farm involved laboratory-confirmed cases.

Reported animal mortality rates for 1998 and 1999 are given in Table 7-4. These are comparable to rates reported on farms elsewhere[19,20].

Table 7-4: Reported average farm animal mortality rates (%) for 1998 and 1999 (49 questionnaire returns).

Year	1998	1999
Dairy Cows	2.6	3.2
Suckler Cows	2.0	3.5
Calves	5.3	5.7
Heifers	1.9	0.5
Bullocks	3.6	0.6
Bulls	0.0	0.0
Sheep	3.9	3.6
Horse	0.0	0.0

.4 DISCUSSION

.4.1 *Blood and tissue analysis results*

The results of these investigations have shown no evidence of a widespread problem of lead toxicity in the area. By the end of 1999, lead analysis had been carried out on blood or tissue samples from cattle in 65 herds, representing 84 of the 96 holdings identified within the area of interest. The great majority of blood samples (~ 94%) had lead concentrations within the normal range. Only 13 of the 61 farms blood-sampled had one or more blood lead concentrations above the pre-determined threshold value of 1.2 μmol/l. Of these, only four had more than three samples with raised values.

Although a further four farms were identified which had one or more above-normal tissue-lead concentrations (> 2 mg/kg), there is no evidence at this stage that any of the farms had a history of lead-related illnesses. This is perhaps surprising in the case of the farm which had tissue lead concentrations values of between 5 and 10 mg/kg. These are generally considered to be consistent with toxicity (Table 7-1) This latter finding emphasises the need to take account of both clinical and analytical findings in the diagnosis of lead poisoning.

The observation that dry stock tended to have higher blood lead concentrations than cows is of interest and probably reflects differences in grazing management leading to higher soil – and therefore lead - intake by the former. Pastures used for dry stock are likely to be shorter and have a greater tendency to poaching than those used for cows. Rotational grazing of dairy cows, on the other hand, is likely to reduce their exposure to localised areas of lead-enriched pastures.

.4.2 *Animal health*

The blood and tissue analysis results are also consistent with the findings of the animal health investigations in the area. The results of the questionnaire survey, together with information collected from herdowners and veterinary practitioners, do not provide any evidence to suggest either that the area had experienced unusual animal health problems in recent years or that cases of lead toxicity in animals were widespread. Diseases reported comprised those common on farms elsewhere and, while incidence rates could not be determined, there was no evidence to suggest that occurrence was unusually high. Of the 49 herdowners who returned completed questionnaires, only five reported cases of lead poisoning over the two-year period 1998 – 99.

Although there was no evidence during the course of the present investigation that clinical copper deficiency was perceived to be a significant problem in the area, a high proportion of blood samples had copper concentrations below the recommended reference range – some well below. This is an important finding and likely to be of significance in relation to animal health and productivity - particularly where performance (i.e. growth, fertility, milk production) is below expectations. Copper therapy is generally recommended for animals with serum concentrations below 9.4 µmol/l.

.4.3 Sources of recent outbreaks of lead poisoning in the Silvermines area

Potential geochemical sources of elevated lead (i.e. soils or river sediments) were identified on the majority of those farms which had one or more above-normal blood or tissue lead concentrations (*see* Appendix 7.2). The two farms which had reported multiple outbreaks of lead poisoning over the past two to three years (Farms A and B) were both located in the Shallee area where some of the highest lead concentrations were recorded on or near agricultural lands. Although no diagnostic material was submitted for laboratory analysis from the 1998 outbreak on Farm B, the history suggests that the source of lead was probably river sediment. The animals in question had access to watercourses which had passed close to areas of mining waste further upstream. The history of the April, 2000 outbreak is also strongly suggestive of an environmental (i.e. river sediment or soil) source for the lead (*see* also Section 4.8.2.8).

Several geochemical sources of elevated lead concentrations have been identified on or adjacent to the farm which reported cases of lead poisoning in early 1999 (Farm A). These comprise the TMF at Gortmore (samples up to 15,540 mg/kg lead recorded; *see* Chapter 3), the old Shallee tailings pond (up to 3,843 mg/kg lead September, 1999, up to 15,000 mg/kg, October, 1999; *see* Chapter 3), and pasture soils on the farm itself (up to 16,450 mg/kg lead, May, 1999; *source* Teagasc).

However, it is difficult to determine which of these may have been responsible for the individual deaths. The animal affected in January was a cow which was housed and had been on silage for the previous two months. The fact that only one animal was affected, suggests that contamination was localised. However, the possibility of individual susceptibility, or the presence of unidentified trigger factors (e.g. hypomagnesaemia), must also be accepted.

Potential sources of lead comprise silage and the piped water supply. However, the latter can effectively be ruled out as, while lead concentrations in excess of the limits for human consumption were detected in the group water scheme in question (*see* Section 6.2.4.1), it is highly unlikely that adult cattle could have received a toxic dose from this source. Although no lead analysis results are available for the silage on which the cow was feeding (the 1998 crop), there was a potential for contamination. In the first case, soil samples collected on or near fields used for production of the silage in question had lead concentrations of up to 16,450 mg/kg (*source* Teagasc). Secondly, some of the silage was produced on fields adjacent to the Gortmore TMF and could have been subject to dust-blows prior to harvesting. However, against the possibility of silage having been the source, it must be noted that lead concentrations in samples from the 1999 crop, which originated from the same fields as the 1998 crop, were not in the toxic range (*see* Chapter 4). The possibility of localised contamination of silage by man-made sources of lead (e.g. lead batteries, etc.) must also not be ruled out.

The three animals which died at the end of April, 1999 had been turned out onto grass five days before the first death occurred. Prior to this they had been on the same silage crop as the cow that died in January, 1999. Potential sources of excess lead comprise silage (prior to turnout), contaminated dust blows onto herbage, and pasture soils. One of the three affected animals also had access to a stream which separated the field from mine waste near the old Shallee workings (lead content of stream sediment samples up to 9,184 mg/kg – *source* EPA).

Although the animals had been off the silage for about five days prior to death, the possibility that it had provided the source of the lead cannot be ruled out. The possibility that a triggering event such as unaccustomed exercise after turnout resulted in a sudden release of lead body-stores followed by acute toxicity must also be considered.

While no lead analysis data is available for herbage in the fields where the deaths occurred, samples collected less than two weeks after the incident - from fields on a line between those grazed and the

Gortmore TMF - had concentrations ranging from 0.33 to 36.4 mg/kg. These would neither pose a significant risk of toxicity for livestock nor would they suggest recent contamination by dust-blows from either of the tailings areas. However, given the time interval between the deaths and sample collection, the possibility of earlier dust blows cannot be ruled out. While wind direction was predominantly westerly prior to turnout of the cattle, it was light easterly to north-easterly (i.e. from the Gortmore TMF towards the pastures) from turnout until the deaths occurred – though it should be noted that the results of dust monitoring in the area in 1999 - 2000 showed no evidence that the lead content of deposited dust was influenced by wind direction during that period (*see* Section 3.5.4).

Dust monitoring on the farm itself commenced in August, 1999 ($Farm_{300}$, $Farm_{600}$; Table 3-8). No exceedences of the TA Luft limits have been recorded to date at these locations. There is no evidence that significant concentrations of dust were blown from the TMF at Gortmore and deposited on adjacent lands during the period of monitoring. Although monitoring at the West side of the TMF at Gortmore (gauge W_a, *see* Table 3-4), which commenced in March, 1999, identified two periods where TA Luft limits for lead deposition were exceeded, these were most likely caused by rehabilitation works undertaken adjacent to the gauge during that period. While the possibility that dust blows from the Gortmore TMF contributed to these animal deaths cannot be ruled, the results of dust monitoring to date would suggest that this is an unlikely explanation.

Soil samples collected in May, 1999 from the field where two of the three animals died had a mean lead concentration of 2,360 mg/kg. Depending on soil intake, this could provide a daily intake of up to 12 mg lead per kg. body weight which is twice the toxic cumulative dose quoted by Puls[21]. However, it should be noted that the dose referred to by Puls would appear to have been based on exposure over several months[22] - and involved smelter dust which is probably of much higher availability than un-worked geochemical lead and tailings waste. Using galena – in which the lead is of comparable availability to environmental sources in the Silvermines area - Alcroft[23] failed to induce clinical signs of toxicity in two weanlings fed either 250 or 500 mg lead per kg. body weight, daily, over a two or three-month period. It is therefore difficult to see how lead intake of a much lower order (i.e. up to 12 mg per kg. body weight) could have provided a toxic dose for grazing adult cattle in under a week.

In conclusion, while the lead responsible for these animal deaths on Farm A in 1999 was most likely geochemical in origin, it is not possible to determine its exact origin, i.e. soil, tailings waste, or river sediment. The possibility, however unlikely, that the lead was not geochemical in origin (e.g. batteries, paint, etc.) can also not be completely ruled out.

.4.4 Relationship between environmental lead and concentrations in animal blood and tissues

The high degree of correlation between mean blood and soil lead concentrations per farm demonstrates that blood lead analysis is a valid means of monitoring environmental lead intake in grazing animals. Blood lead analysis was, however, only moderately successful in identifying individual farms with elevated lead concentrations. Of 20 farms with maximum soil lead concentrations in excess of 900 mg/kg, for example, only 11 had one or more raised blood values (> 1.2 μmol/l). This can at least partly be explained on the basis that cattle on some of these farms may not have had access to the lead-enriched soils in question during the period immediately before blood-sampling.

Although there was a relatively poor correlation between tissue and either soil or blood concentrations, this can probably be largely accounted for by differences between blood and tissue in terms of lead metabolism. Blood lead is an indicator of recent intake (i.e. days to weeks); tissue lead, on the other hand, reflects longer-term intake and tends to be higher in older animals. The raised tissue results from the two farms with no above-normal soil or blood values were derived from single, aged cows in each case, and would have represented a lifetime intake of lead from a variety of sources.

.5 CONCLUSIONS

- The animal health investigations have shown no evidence of a widespread problem of lead toxicity in animals in the Silvermines area.
- Significant reported outbreaks of lead poisoning in recent years were limited to two farms located in an area with some of the highest environmental concentrations of lead (soil, river or drain sediment, mine waste).

- A number of other farms were identified which had one or more raised animal blood or tissue lead concentrations. Most of these farms are located in or near defined areas of elevated environmental lead concentrations. Lead poisoning was not reported to have been a problem on these farms.
- The risk of sporadic outbreaks of lead poisoning will persist on the small number of farms with access to the highest concentrations of environmental lead. Control measures to reduce this risk are outlined below.

.6 RECOMMENDATIONS

- Further evaluation will be required on some farms with elevated blood or tissue lead concentrations in order to more precisely identify environmental and other factors contributing to excess lead intake. A management system designed to minimise lead intake by food animals should be drawn up by DAFRD and Teagasc for each affected farm (*see* Chapter 4).
- Details of a generally applicable regime of grazing and other farm management controls (including access to streams, etc.), designed to minimise lead intake by animals, should be made available by Teagasc to all farmers in the area.
- In the case of calves, which have a higher susceptibility to lead poisoning, particular attention should be paid to the implementation of farm management controls given in this report.
- A targeted programme of blood-sampling and analysis should continue in the area in order to more fully assess the impact of environmental lead on animal health. This will be subject to ongoing review.
- In order to assist in the accurate identification of cases, herdowners in the area, and their veterinary practitioners, should make available for laboratory examination carcasses of animals which are suspected of having died from lead poisoning.
- As in the case of farm animals, care should also be taken to protect the health of domestic and companion animals.
- Based on the results of the recent blood-sampling programme, particular attention should be paid to the copper status of farm animals in the area.

.7 ACKNOWLEDGEMENTS

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Appendix 7.1

Bovine submissions to Limerick RVL from Silvermines area 1992-1999.

Date	Lab. Ref.	Submission	Diagnosis	Lead Analysis*
16/03/92	92L975	Calf	Lead Poisoning	39.8 mg/kg (K)
12/04/94	94L1633	Calf	Lead Poisoning	10.6 mg/kg (K)
25/04/94	94L1806	Calf	Lead Poisoning	6.9 mg/kg (K)
02/05/95	95L2054	Heifer	Blackleg	1.0 mg/kg (K)
12/12/95	95L4235	Heifer	Enteritis	1.1 mg/kg (K)
04/04/96	96L1636	Calf	Lead Poisoning	29.6 mg/kg (K)
24/11/97	97L3845	Heifers x 2	Nitrate Poisoning	1.7/2.2 mg/kg (K)
11/01/99	99L153	Cow	Lead Poisoning**	12.9 mg/kg (K)
18/01/99	99L271	Bullock x 2	Yew Poisoning	6.6 mg/kg (K)
29/04/99	99L2136	Bullock	Lead Poisoning**	8.4 mg/kg (K)
30/04/99	99L2169	Bullock	Lead Poisoning**	10.5 mg/kg (K)
03/06/99	99L2484	Blood x 3		0.18-0.26 μmol/l (B)
14/06/99	99L2553	Blood		0.5 μmol/l (B)
17/06/99	99L2606	Cow	Ragwort	1.9 mg/kg (K)
22/06/99	99L2649	Cow	Ragwort	1.8 mg/kg (K)
23/06/99	99L2658	Heifer	Ragwort	1.2 mg/kg (K)
24/06/99	99L2679	Calf	Osteomyelitis	2.5 mg/kg (K)
26/06/99	99L2699	Cow	Ragwort	2.3 mg/kg (K)
26/06/99	99L2700	Cow	Ragwort	2.0 mg/kg (K)
29/06/99	99L2726	Cow	Ragwort	1.9 mg/kg (K)
19/07/99	99L2865	Blood		1.8 μmol/l (B)
23/08/99	99L3138	Calf	Lead Poisoning	11.8 mg/kg (K)
27/08/99	99L3195	Bullock	Salmonellosis	1.3 mg/kg (K)
13/09/99	99L3338	Bullock	Blackleg	2.0 mg/kg (K)
23/09/99	99L3451	Cow	Abdominal Abscess	2.2 mg/kg (K)
08/11/99	99L4058	Calf	Blackleg	3.6 mg/kg (K)

* K = kidney, B = blood. All tissue analyses were performed on kidney cortex.
Normal range for blood = 0 – 1.2 *μmol/l*. Normal range for kidney = 0 – 2.0 *mg/kg*
** All these cases were from one farm.

Appendix 7.2

Summary blood (first and re-visit samplings) and soil lead analysis results for farms with one or more above-normal blood and/or tissue values.

Farm Code	Blood lead (µmol/l)		Environmental lead (mg/kg)[1]	Elevated bloods[2]	Elevated tissues[3]
	Mean	Range			
A	1.35	0.62 - 2.94	5369.50	23 (39)	1 (16)
B	1.00	0.29 - 1.77	4493.14	9 (21)	
F	1.71	1.03 - 2.55	1617.60	7 (8)	
R	1.23	0.72 - 2.55	NA	2 (8)	
H	0.88	0.51 - 1.49	2163.60	1 (10)	
P	0.84	0.45 - 1.92	404.70	3 (27)	
S	0.84	0.53 - 1.38	252.60	2 (11)	
M	0.64	0.31 - 1.73	2985.28	1 (11)	
D	1.24	0.08 - 4.06	4054.50	17 (37)	
N	0.56	0.16 - 1.38	4491.70	1 (10)	
K	0.89	0.44 - 1.33	4493.10	3 (7)	0 (6)
G	1.03	0.62 - 1.69	900	3 (12)	0 (3)
J	1.01	0.90 - 1.22	999.40	1 (4)	0 (2)
C	0.67	0.08 - 1.68	931.00	3 (45)	9 (15)
Q	0.41	0.08 - 1.17	1489.00	0 (14)	2 (26)
T	0.28	0.20 - 0.54	421.50	0 (10)	1 (4)
E	0.12	0.08 – 0.4	54.50	0 (31)	1 (15)
V	NA	NA	NA	NA	1 (33)

[1] Highest soil sample on or adjacent to holding.

[2] > 1.2 µmol/l. Total number animals sampled in brackets.

[3] > 2.0 mg/kg; total number analysed in brackets.

NA = not available.

Chapter 8

Mining-Related Sites and Future Management

.1 BACKGROUND

The long history of mining in the Silvermines area has left its mark on the economy and environment. As indicated in Chapter 1, most of this mining was outside the realm of the Minerals Development Acts. Equally, most of this mining lay outside the realm of the Planning and Development Acts which commenced with the 1963 Act. Mining in the area which was subject to the Minerals Development Acts comprised portions of the activities of Mogul of Ireland Ltd. (Mogul) and the underground operations of Magcobar (Ireland Ltd.). Each of the major mine complexes in the area is dealt with below.

.2 MOGUL TAILINGS MANAGEMENT FACILITY AT GORTMORE, BALLYWILLIAM.

.2.1 Historical background

Mogul developed a base metal mine in the Silvermines Area in the mid-1960s. Lead and zinc were the primary metals extracted in the underground mining operation. When metal concentrate is extracted from rock through an ore-processing mill it leaves a material ranging from fine to coarse sand–sized particles called tailings. As not all the ore is extracted from the rock, zinc and lead, together with other minerals, will be present in the tailings. Tailings from the Mogul mine were transported *via* a pipeline as a slurry to the TMF at Gortmore, located 4.5 km from Silvermines village and 3 km from the mine site at Garryard (*see* Map 3). Here the suspended solids settled out and the water on top was decanted. Some of this water was pumped back for re-use at the mine. The balance was released through a series of reed beds which removed residual fines and some dissolved metal salts from the water.

About nine million tonnes of tailings was generated, most of which was disposed of at the TMF. Construction of the TMF commenced in 1966 and it was first used in 1968. Filling was completed by 1982. The TMF is on a site of 76 hectares (188 acres) with the area of the tailings covering 59.3 ha (146 acres) enclosed by an embankment. The TMF represents approximately 3% of the total area (c. 2,300 ha) included in this investigation. Throughout this report references to the tailings at this site or to the TMF mean the material enclosed by the embankment.

When the Mogul mine ceased production in 1982, the pipeline was dismantled and rehabilitation of the surface of the TMF was not required under any legislation. The surface of the TMF dried out gradually following the cessation of the pumping of tailings and a dust blow occurred from the surface in the summer of 1984. This was subsequently followed by a major dust blow in February, 1985. A family residing beside the TMF moved to another premises and advice was given on the use of locally-grown vegetables. Lead concentrations above normal background were recorded on herbage and in blood samples from livestock in 1985.

Following discussion with TNRCC during the summer of 1984, Mogul commissioned environmental consultants to investigate the extent of the dust blow and to advise on possible rehabilitation. The experts undertaking the work stated that the tailings were chemically complex and secondary salinity would be an issue during rehabilitation. Work was scheduled to commence in spring of 1985, but in response to the major dust blow in February, 1985, 54 cubic metres of bitumen was sprayed on the perimeter bank and edge of the tailings to stabilise the surface. In March 1985, work commenced on the surface of the TMF to establish a self-sustaining grass cover. Trial plots were established to evaluate the most appropriate grass-seed mix, fertiliser and planting method. Seeding of the surface of the TMF was completed in September, 1987.

There is no record of any serious dust blows from the TMF since 1987. However it is clear that the objective of establishing a self-sustaining grass cover over the entire surface area and embankments has not been achieved. In early 1999, it was estimated that somewhere between 10 and 25% of the surface of the TMF had poor or no grass cover, with most of the embankment wall having no cover. Grass failure may be due to a to a number of factors which include the generation of acid at the surface due to the high pyrite content of some of the tailings, salinity, nutrient deficiencies, surface water-logging and water shortage in dry periods.

In September, 1998, Mogul sold the TMF lands to a farmer, who subsequently constructed an access ramp on the north embankment and allowed sheep to graze the surface of the TMF. Concern was expressed that uncontrolled grazing would damage and reduce the grass cover further, and that the construction of the ramp may have damaged the structural integrity of the embankment. In response to these concerns the farmer was required by TNRCC to remove the access ramp, make repairs to the embankment, and remove the sheep

.2.2 *Analysis of the tailings at the TMF*

The chemical composition of the tailings reflects the chemistry of the host rock, the ore mineralogy, and the processes used to extract the metals. The chemical and physical nature of the tailings is one of the factors influencing sustainable grass cover on the TMF. The formation of acid on the surface of the tailings depends on the relative proportions of pyrite (acid-type mineral) to dolomite-calcite (alkaline minerals) in the rock. This varied from place to place in the mine and the variability is reflected in the tailings produced and deposited at different times in the TMF. The worst affected area is the NW corner of the TMF, with other bare areas occurring at random across the surface of the TMF.

As part of their soil and herbage sampling for the present investigation, Teagasc have sampled and analysed the surface layer of tailings in the TMF. Samples were taken at a depth of 10 cm and analysed for lead, zinc, cadmium and arsenic. The results are summarised in Table 3-1 and Table 4-2.

The variation in results reflects the depositional history of the tailings. Some parts of the mined ore contained more pyrite than others, leading to tailings correspondingly high in pyrite. The depositional history also indicates variability in particle size-distribution within the TMF, with coarser particles being deposited around the edges while silt and clay-sized particles were deposited towards the centre[1].

.2.3 *Developments during 1999/2000*

In January, 1999, as indicated in Chapter 1, the EPA published its “Report on investigation of recent developments at Silvermines Tailings Management Facility, Co. Tipperary”[2]. In response to the TNRCC request under Section 55 of the Waste Management Act, 1996, Mogul submitted a draft “Risk Assessment and Rehabilitation Plan” for the TMF in July 1999. TNRCC, assisted by the EPA, examined the plan and requested revisions to include missing items in the risk assessment and to overcome inadequacies in the rehabilitation proposals.

In July, 1999, Mogul commenced works on the TMF to cover the bare areas with gravel sub-soil sourced from an area adjacent to the south west of the TMF. Similar material was also used to cover part of the embankment wall on the Southwest side of the TMF. This material was subsequently sown with grass seed and fertilised. However, grass establishment to date has been poor.

In October, 1999, TNRCC, DMNR, Teagasc, and the EPA assessed the effectiveness of the work undertaken on the TMF by Mogul during 1999. It was clear that the work programme undertaken, which was based on the proposals developed in the late 1980s, had not succeeded in promoting grass cover on the bare areas of the TMF. It was considered that significant technical issues had to be addressed before the rehabilitation of the TMF could be successfully completed. These issues include establishing the cause of grass die-back, determining appropriate remedial measures to prevent its recurrence, and determining the effect of machinery traffic on the surface and along the embankment walls. Teagasc also indicated following the site visit that agriculture may not be the most appropriate after-use for the TMF where the primary objective of rehabilitation is to stabilise the surface and prevent further dust blows. Alternative uses which did not include grazing, such as managed nature reserve or wetlands etc., should be considered. It was considered that metal concentrations in the TMF may preclude the safe grazing of animals on the area without controls being put in place.

It was considered by the DMNR that the work programme necessary for the successful long-term rehabilitation of the TMF could not be established without a detailed technical investigation being carried out. As a result, the Risk Assessment and Rehabilitation Plan was essentially put on hold pending outcome of detailed technical investigations.

.2.4 *Future rehabilitation and management of the TMF at Gortmore*

The DMNR has established that, under Clause K of the State mining lease issued in 1965 to Mogul, under the Mineral Developments Acts 1940–1960, the Minister may require specific works to be carried out on a once-off basis to rectify the lands affected by the lessee's mining activity. That lease expired in December, 1998, although mining had ceased in 1982.

In December, 1999, the DMNR put Mogul on notice of its liability under Clause K. The DMNR has commenced a detailed technical study of the various mines and mine tailings facilities in the Silvermines Area. This investigation will also address the technical issues involved, identify ownership of lands and private minerals and the responsibilities of DMNR, Mogul, and others, in the area. A schedule of works will be drawn up from this investigation for presentation to Mogul under Clause K. A summary of plans and future actions for the TMF is given in Appendix 8.1. The timescale for the DMNR programme is shown in Appendix 8.2

.3 INTERIM MANAGEMENT OF THE TMF AT GORTMORE

Pending final rehabilitation of the TMF under Clause K, the TMF will be managed by Mogul under a "Monitoring and Emergency Plan" (Appendix 8.2) and supervised by TNRCC. The aim of this plan is to manage risks to the environment, animal and human health associated with the TMF. This plan involves weekly and, in certain circumstances, daily environmental and security monitoring and regular reporting to TNRCC. Where an increased risk of dust blows or other environmentally damaging discharges from the TMF has been identified this will trigger the implementation of the emergency plan which is designed to mitigate these risks. The plan also includes details on covering existing bare areas and fertilising grass.

This plan will be revised and adapted as necessary. This will ensure the effective protection of human and animal health and the environment.

.4 MAGCOBAR MINE SITE

The Magcobar mining company operated an open-cast barite mine at Garryard West-Gortshaneroe between 1963 and 1993 (Map 3). The surface area of the open-cast mine is approximately 15 hectares and the excavation approximately 70 m deep with a capacity of 7 million cubic metres or thereabouts. The excavation has largely filled with surface and ground water since the mine closure in 1993.

The Magcobar site has been acquired, subject to receiving planning permission and other statutory approvals, by Waste Management Ireland Ltd. The company proposes the development of a landfill facility on the Magcobar site and has applied to TNRCC for a discharge licence to pump out water from the open-cast mine to the Foilborig Stream and for planning permission for a landfill facility on the site.

TNRCC, in exercise of the powers conferred on it by the Local Government (Water Pollution) Acts 1977–1990, granted a licence to the company on 8 October, 1999 to discharge trade effluent, subject to forty two conditions. These conditions were considered necessary to ensure the discharge would not cause pollution of the receiving waters and also that the rate of discharge would not exceed the capacity of the Foilborig Stream. Waste Management Ireland Ltd appealed the licence conditions to An Bord Pleanála and the Council's decision was also appealed by a number of local landowners, residents and interest groups in the area.

TNRCC refused planning permission for the development of a landfill facility on 10 November, 1999. Waste Management Ireland Ltd has appealed the Council's decision to refuse planning permission to An Bord Pleanála. The EPA is considering an application for a Waste Management Licence for this project.

.5 SHALLEE LEAD MINE

Mining was carried out in the Shallee area, three km west of Silvermines in the 19th century. The Silvermines Lead and Zinc Company re-commenced mining in 1949 and these workings continued until 1953. The Shallee mine re-opened in 1955 and finally closed in 1958, producing, during that period in excess of 350,000 tonnes of ore. Mining at Shallee was primarily for lead and there is little evidence of pyrite in the mineralized rocks. The tailings associated with historic mining here are not acid-generating and some currently sustain grass and shrub growth. A small portion of the tailings is exposed adjacent to Shallee crossroads and shows evidence of recent excavation.

Shannon Development (SFADCo Ltd.), the semi-state body charged with industrial development and tourism promotion in the Mid-West Region, recognised the potential this site has for attracting tourists interested in heritage to the Silvermines area. The company proposes the development of a National Mining and Heritage Centre located at the site of the old Shallee Lead Mine. The proposed development includes a visitors centre which will provide visitors with access to mine workings. TNRCC granted planning permission in May, 2000.

.6 MINING COMPLEX AT GARRYARD

Mogul operated a major base-metal mine at Garryard from 1968 – 1982 producing in excess of 10 million tonnes of ore. The mine-works site includes settlement ponds, a tailings lagoon and the mill where ore processing operations were carried out prior to export of concentrates for smelting.

The mining company disposed of the lands at the Garryard site in the period 1984 - 1999. The present owners of the lands between the railway and the road commenced site clearance works in October/November, 1999. The site includes a settlement pond at the entrance, which may have been used as a settlement pond for water run-off from the mine site. There is also an area north of the railway line where tailings were deposited in a lagoon by Mogul prior to the construction of the Gortmore TMF. The lagoon varies in size with change in water level and is bordered by mounded tailings. Throughout this Report references to this lagoon include these tailings. Substantial areas of these tailings are uncovered, with little or no vegetation cover. The risk of future dust blows, and the metal content of waters and sediment draining from this site, merit further investigation. The determination of ownership and liability in relation to the wastes on this site are part of the area-wide investigation which has been commenced by the DMNR and referred to in Section 8.8 below.

On 23 November, 1999, TNRCC served a Section 26 Notice under the Local Government (Planning & Development) Act, 1976 requiring the new owners of the mine yard to cease development work on the site. The owners were also advised that any disturbances of the settlement pond on the site could be environmentally damaging. Work on the site was discontinued as requested.

.7 MINING COMPLEX AT SILVERMINES VILLAGE

Calamine (Zinc Oxide) was mined in the 19th and early 20th century at Ballygowan near Silvermines village in the area between the Knockanroe and Lahid roads. Mine buildings and tailings are evident in this area where the Silvermines Lead and Zinc Co. established a processing plant in the early 1950's to treat waste from the earlier phases of mining. Production of Calamine ceased in 1951.

.8 EXTENT OF SPECIALIST STUDIES

It has become evident in the course of this study that it is necessary to quantify the extent and location of mining residues throughout the Silvermines area. Accordingly, DMNR has widened the scope of its detailed technical investigation, which was originally intended to draw up the schedule of works referred to in Section 8.2.4, to include all residues, structures, openings and subsidence arising from mining of State and private minerals in the area. In the course of that study DMNR will also establish the ownership of lands and liability for works that may be needed. Any deficit in the powers of the Minister for the Marine and Natural Resources and other public authorities to have the necessary works carried out will be identified. The time frame for completion of this study is shown in Appendix 8.2.

.9 DISCUSSION

While noting the long history of mining in Silvermines, and acknowledging the complex legal and technical issues which arise in the rehabilitation and long-term management of old mine workings in the area, the IAG is concerned that such sites can pose largely unmanaged risks many years after mining operations have ceased. In particular, the IAG considers it regrettable that almost 20 years after the cessation of mining operations, the Gortmore TMF, which was described in the 1999 EPA Report as "*… a perpetual risk to human health and the environment …*", has yet to be satisfactorily rehabilitated and subjected to a long-term management plan. The IAG notes that advances in mining technology and in the regulatory environment in recent years should ensure that such situations are unlikely to arise where more modern mining operations are involved, although such an observation is strictly not of relevance to addressing the issues which arise in the Silvermines area.

.10 RECOMMENDATIONS

- Mogul should manage the Gortmore TMF under the emergency plan agreed with TNRCC pending final rehabilitation.

- The settlement pond and tailings lagoon at Garryard, the unvegetated tailings at Shallee, and the TMF at Gortmore, should all be securely fenced pending formulation and implementation of management plans for each site.
- Management plans for each historic mine site in the area, including the former mining complex above Silvermines village, should be formulated by consultants employed by DMNR by the end of 2000.
- Other high-lead areas in the Silvermines area should be identified and environmental management plans formulated and implemented for them.

.11 REFERENCES

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2. **EPA.**. Report on investigation of recent developments at Silvermines Tailings Management Facility, Co. Tipperary. EPA, Wexford. 1999.
3. **Mogul of Ireland Limited**. Environmental Risk Assessment and Rehabilitation Plan for Silvermines TMF. Mogul of Ireland Ltd, Dublin. 1999.

Appendix 8.1

Summary of plans and future actions for Gortmore TMF

Plan/Action	Date	By	Purpose	Progress
Environmental Risk Assessment (ERA) and Rehabilitation Plan (RP) for TMF.	July 1999	Mogul	ERA to identify risks associated with TMF. Rehabilitation plan for TMF to minimise and manage risks.	TNRCC and EPA assessed the contents of the risk assessment and rehabilitation plan in August 1999. Mogul was informed that the risk assessment was incomplete in respect of a number of items and the rehabilitation plan was not adequate to ensure sustainable long-term establishment of grass on the TMF. Additional information was supplied by Mogul in January 2000. This risk assessment and rehabilitation plan remains incomplete and has since been superseded by the requirement under Clause K of the State mining lease.
Revised ERA and RP	January 2000	Mogul	More comprehensive look at risks. Provide assurance on sustainability of sward	Implementation and further assessment deferred pending detailed analysis of TMF as part of DMNR area wide study.
Mogul put on notice of its liability under Clause K of state mining lease.	December 1999	DMNR	Expiry of the lease allows the Minister to require Mogul to carry out works to rectify lands affected by the working of State minerals..	DMNR study required to prepare Schedule of works.
Background Report.	January 2000	Mogul	To provide detailed information on the studies and rehabilitation works that were undertaken on the TMF following the dust blows in the 1980s.	Input to DMNR study (as above).
Monitoring and Emergency (M&E) Plan	January 2000	Mogul	To reduce the risk of dust blows pending definitive rehabilitation.	Discussion with TNRCC, DMNR and EPA to improve plan .
Final M & E Plan	June 2000	Mogul	Sets out monitoring and emergency plan procedures.	Agreed with TNRCC June 2000. Will be adjusted as necessary from time to time by agreement between Mogul and TNRCC.
Preliminary characterisation study	May 2000	DMNR	To identify all residues, structures, openings and subsidence arising from mining of state and private minerals in the area (includes TMF)	Characterisation study (identification of mining related sites) completed.
Schedule of works under Clause K	January 2001	DMNR	Convey to Mogul Minister's requirements of works to rectify lands affected by mining of State minerals and timescale within which works are to be completed.	Awaits area wide study for DMNR

Appendix 8.2

Schedule for completion of Specialist Studies

Action	Date
1. Survey of the area from Silvermines to Shallee cross roads and detailed map completed. (Characterisation Study).	by mid May 2000
2. Identify source material.	by end May 2000
3. Invitation to tender for contracts.	to issue early June 2000 for return by end June 2000
4. Assess tenders and place contract.	by end July 2000
5. Reports giving management plans, rehabilitation proposals and conservation works to be completed by consultants.	by mid December 2000
6. Minerals ownership and land ownership studies and identification of responsibilities of owners, agencies etc.	June – November, 2000
7. DMNR will agree management plans with TNRCC and other relevant agencies.	by mid January 2001
8. The Schedule of works for Mogul under *Clause K* to be completed and settled with Counsel.	by end January 2001
9. Finalise time-scale for and commence agreed works (in each case, works will be supervised by DMNR or relevant agency): Clause K works (Mogul); other works (identified partners).	 February 2001 February 2001

Progress reports on all plans and works in the area shall be given regularly to the Implementation Group proposed in Recommendation 38 of this Report and, through that Group, to Government and the local community.

Appendix 8.3

Monitoring and Emergency Plan for Gortmore TMF

Monitoring and Emergency Plan 2000
for
Silvermines TMF

Prepared on behalf of Mogul of Ireland Ltd. and agreed with TNRCC

INTRODUCTION

The Silvermines Tailings Management Facility (TMF) is located in Gortmore townland, 8 kms Southwest of Nenagh, in County Tipperary. The site is on the northern side of the Kilmastulla River and is 1.25 kms from the main Limerick-Nenagh road and a secondary road. The TMF comprises an area of 76.14 hectares (188.24 acres) with the area of the tailings enclosed by 10m high embankments equal to 59.3 hectares (146.53 acres).

This report details the procedures that are in place to address potential hazards associated with the TMF. These procedures contain two elements:

1. Monitoring of all aspects of the TMF, and
2. An emergency plan to deal with any potential dust emissions.

BACKGROUND

Construction of the TMF commenced in 1966 and it went into operation in 1968 when processing commenced in the mill at the mine. The embankment of the TMF was built up by the standard “upstream” method using waste rock and coarse tailings. The mine closed in 1982 and the pipeline from the mill was removed.

The TMF was acquired by the current owners of Mogul in 1984. Dust blows from the surface of the TMF occurred during the summer of 1984 and in February 1985. A rehabilitation and research programme was initiated by Mogul in 1985 and it succeeded in growing grass directly on all of the tailings by the end of 1987. The grass has developed well over most of the TMF but it has died in some areas. The re-vegetation of these areas is achieved by covering them with soil and re-seeding with grass followed by a suitable grass management programme including fertilising.

In 1998, the TMF was sold by Mogul to a farmer and he undertook certain actions at the site. During 1999, Mogul carried out an environmental risk assessment and prepared a rehabilitation plan for the TMF. These were submitted to the Tipperary (North Riding) County Council (“TNRCC”). Mogul also undertook some additional rehabilitation work on the TMF and prepared an emergency plan to prevent dust emissions from the TMF.

The assessment determined that the risk of a significant dust blow from the surface of the TMF is low and this emergency plan is in place to manage the potential problem. Reports by independent consultants have found the structural integrity of the embankments of the TMF to be satisfactory.

A list of reports relating to various aspects of the TMF are included in the references at the end of this report.

Objective

Since the dust blows in the period 1984-1987 the focus of Mogul has been on the elimination of dust emissions from the TMF. This has been achieved by covering the surface of the tailings with grass. To the middle of 1999, approximately 85-90% of the surface was covered with grass of varying quality. However, as long as there are bare areas on the surface of the TMF there is potential for limited dust emissions. The total elimination of this potential will be achieved by the re-vegetation of these areas and the development of a strategy to ensure the self-sustaining growth of ground cover. Until this is achieved an emergency plan will be maintained to deal with the threat of potential dust blows.

The objective of the monitoring and emergency plan is to be pro-active rather than re-active to a dust blow. The plan requires regular inspection of the TMF to identify circumstances when conditions are such that the potential for a dust blow is high. In these circumstances measures will be taken to dampen the surface of the bare areas in order to prevent dust emissions. In addition, further rehabilitation (i.e. covering with soil, grass seeding and fertilising) of the peripheral bare areas as weather conditions permit would reduce the potential for dust blows from these areas. The management of the existing grassed areas will ensure the continued growth and development of the grass cover.

THE MONITORING PLAN

The monitoring plan will have environmental and security dimensions to it. The purpose of the environmental monitoring is to examine the various elements of the TMF related to the dust, water and embankment issues and to identify any variations or deterioration in these components. The security monitoring will focus on access to the site by unauthorised personnel and animals. This must be maintained to ensure that the surface of the tailings is not damaged by illegal trespass.

The environmental monitoring will examine and record:

- The dryness of the surface 10cms of the TMF and the embankment.
- A rain gauge will be installed on the surface of the TMF to measure the amount of precipitation falling between the monitoring inspections.
- The amount of water on the surface of the TMF.
- The effectiveness of the surface drainage.
- The status of the peripheral drains and reed beds, i.e. the level of the water, the flow rate, vegetation content, etc.
- The embankments of the TMF for any sign of slumping or slippage.
- The embankments for evidence of gullying caused by surface water run-off.
- The extent of the ARD at the toe of the embankments.
- The status of the grass cover on the surface of the TMF.

The security monitoring will inspect and record:

- The status of the boundary fences and the access gates.
- The presence of animals at the TMF or evidence that animals had entered the site.

Monitoring and reporting procedures

- The environmental and security monitoring will be completed on a weekly basis by a designated person[*].
- The details will be recorded on an A4 form that contains a plan of the TMF and a checklist.
- The form will be signed and dated by the person who completes the monitoring.
- If unauthorized cattle are present the numbers on the identification tags will be recorded and TNRCC and Mogul will be informed by telephone of the details.
- During dry periods, i.e. after five days of dry weather, the TMF will be inspected on a daily basis.
- The site will be inspected on a monthly basis by a designated person from Mogul. Inspections will be made more frequently when deemed necessary by the weather conditions or when rehabilitation work is in progress.
- The designated person from Mogul will prepare a monthly report on the status of the TMF and send a copy to TNRCC. The report will include copies of the environmental and security monitoring records.
- Water samples will be collected on a quarterly basis to monitor the effectiveness of the peripheral wetlands area as a natural passive treatment system.

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[*] Names of designated personnel can be supplied by Mogul or TNRCC.

THE EMERGENCY PLAN

The purpose of the emergency plan is to have in place a means to prevent dust emissions from the bare areas on the TMF during periods of prolonged dry weather. Experience has shown that dry periods of 14-21 days have not been a problem but the potential for dust emissions increases for dry periods greater than this. One of the major potential sources of dust emissions during extensive dry periods is from vehicular traffic on the TMF. Care will be taken to minimise the volume and frequency of the vehicles involved in the emergency plan. The large bare area in Pond 2, on the Ballywilliam side, will be dampened by a sprinkling system.

- Machinery to be used in the Emergency Plan will be provided by a plant hire contractor.

The Emergency Plan Procedures

- The surface of the TMF and the embankments will be examined on a weekly basis by designated persons. It will be inspected on a daily basis after any five consecutive dry days.
- The inspection will examine the bare areas and determine the moisture level of the tailings.
- The relevant designated person will contact Mogul and TNRCC by telephone when:
    1. There has been a five-day dry period.
    2. The surface of the bare areas has dried out.
    3. The weather forecast is for continued dry weather.
- Inspection of the surface of the TMF will then be made on a daily basis.
- The designated representative of Mogul will then also inspect the TMF on a frequent basis and will authorize the commencement of the emergency plan, when it is warranted.
- In the event that contact cannot be made with Mogul, other designated persons will have the authority to initiate the emergency plan.
- Mogul will inform TNRCC and the landowner of the decision to commence the emergency plan.
- A tractor and water tanker will be used to dampen the bare areas near the margin of the TMF. They will be equipped with wide tyres to improve their trafficability on the surface of the tailings and to minimise any damage that may be done to the grass cover.
- The tractor and tanker will minimise the amount of travelling on the tailings in order to prevent dust emissions caused by the wheels of the equipment on the dry grassed surface. This will be achieved by the machinery using the roadway on the southern side of the TMF.
- The water for the tanker will be obtained from the Kilmastulla River at the bridge adjacent to the entrance to the TMF.
- In Pond 2 there is a large bare area adjacent to the drain that takes the surface water to the settling lagoons, via the decant tower. An irrigation sprinkling system using water from the drain will dampen this area.
- In the event of a prolonged dry spell sufficient water may not be available from the surface drain. In that event, water for the sprinkling system will be obtained from the settling lagoons at the northern side of the TMF or from the Kilmastulla River.
- The bare areas will be watered on a daily basis for as long as the dry period continues.
- Any necessary adjustments to the emergency plan procedures will be as agreed by Mogul with TNRCC from time to time.

CONCLUSION

There have been no reported dust blows from the TMF since early 1987 and the purpose of the “monitoring and emergency plan” is to ensure that this continues. The need for an emergency plan will be removed when the bare areas are re-vegetated. In the meanwhile the effectiveness of the monitoring will be reviewed on a quarterly basis with TNRCC and due consideration given to any recommendations concerning the monitoring frequency.

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Chapter 9

Conclusions and Recommendations

.1 DISCUSSION

The detailed Conclusions and Recommendations of the Inter-Agency Group (IAG) are set out in this Chapter. There are 39 Recommendations under the principal headings of Human Health, Animal Health, Food Safety, Soil, Herbage, Fodder, and Drinking Water (for animals), the Local Environment and Mine-Related Areas. These Conclusions and Recommendations represent the outcome of the investigation and assessment carried out by the IAG. This detailed work has enabled the IAG to make some general comments about the Silvermines area.

As with other locations in the country, both rural and urban, there are risks arising from the particular characteristics of the area which must be managed to ensure the safety of local people. In the case of Silvermines, risks arise from the mining operations, which have been a feature of life in the area for many centuries, and the naturally occurring lead and other metals on which such operations were based. The IAG believes that the Silvermines area is a safe place in which to grow up, live and work, provided that certain precautions are taken. Some of these precautions will require the involvement of public agencies and other interests; others can be taken by local people themselves.

The general reassurance which the IAG believes it can give the people of the area does not seek to minimise or ignore the fact that the legacy of past mining operations poses particular risks. Because of the legacy of past mining operations, it is necessary for the local people to refrain from certain activities - e.g. swimming in local rivers - in order to avoid exposure to risk. It will be particularly necessary to exercise care in relation to the areas of the locality accessed by young children. Care should also be taken in relation to animals. For most people, these precautions should entail little disruption in their way of life.

To the extent that residents of the Silvermines area need to have regard to identified local risks in going about their daily lives, the situation will be similar to that in other areas of the country, both rural and urban. For most people, living safely in the Silvermines area will entail following advice given to them by the public health authorities. For those involved in farming and food production, it will entail following the advice of their veterinary practitioners, DAFRD and Teagasc. The investigation has shown that foodstuffs can be produced safely in the area. Planning and development should also take account of the environmental characteristics of the area.

The IAG concludes that the issues which initiated this investigation are a consequence of elevated lead concentrations in the local environment. These in turn reflect the natural geology of the area and the impact of over a thousand years of mining. In formulating its conclusions and recommendations, the IAG has adopted a precautionary approach. It has also recommended a number of immediate actions which, once taken, will give protection pending the full implementation of the recommendations contained in this report.

Overall, the IAG considers that while there are risks arising from certain characteristics of the Silvermines area, these risks can be clearly identified and managed. Once the necessary strategies to manage the risks in question have been drawn up, the actual process of risk management in the area will fall to be undertaken by local and national public agencies, by the local community, and by local people as individuals and others. Effective management of risk into the long term will require the positive, committed co-operation of all concerned.

.2 CONCLUSIONS

.2.1 Human Health

1. Based on the results of the blood testing programme, the IAG concludes that there is not a human health problem in the area related to lead. Blood lead concentrations, including among young children, were found to be generally within current international standards. A total of 683 screening blood samples were taken of which seven samples exceeded the acceptable limit - four being 'borderline' and three being slightly elevated. The results indicate to the IAG that the elevated environmental lead (i.e. soil, water and sediments) concentrations which have been found at certain locations within the area

are not being transferred to the human population. Nevertheless the IAG does not believe there are grounds for complacency.

2. The IAG considers that the characteristics of the area are such that appropriate precautionary or protective measures should be taken to protect human health and ensure that lead in the locality will not create a problem in the future. Children are more vulnerable to the effects of lead. The IAG has therefore taken a more conservative and precautionary approach to environs where children are required to be present. The IAG has concluded that there should be active intervention as soon as possible in the vicinity of Silvermines school, involving fencing and resurfacing. People living and working locally, whether engaged in farming or not, should integrate into their daily living routines a number of simple, practical precautions, based on advice from the relevant agencies. Particular attention is required where young children are concerned.
3. The IAG has concluded that more information about soil lead concentrations in or close to residential areas and consequent further evaluation of risk management strategies is needed. The IAG considers it necessary that human health in the Silvermines area be periodically monitored. The IAG believes that as soon as possible an expert group should be asked to formulate guidelines applicable to Ireland for the management of lead in the environment.

.2.2 *Animal Health*

1. The results of blood and tissue sampling of animals from farms in the area encompassed by the investigation led the IAG to conclude that there is no evidence of a widespread problem of lead toxicity in animals.
2. A review of the historical records of the Regional Veterinary Laboratory (RVL) in Limerick for the 1992-99 period, the information obtained from animal health questionnaires returned by farmers in the area as part of the investigation, and contact with Private Veterinary Practitioners (PVPs) who service farmer clients in the area, have not indicated to the IAG a widespread clinical lead poisoning problem.
3. Lead concentrations found in the blood and tissues of animals have tended to reflect the lead-related characteristics of the farms on which they have been kept. In most cases, animals with elevated lead concentrations in blood or tissues originated from farms on or near areas where elevated concentrations of environmental lead were found.
4. The risk of sporadic outbreaks of lead poisoning will persist on the small number of farms with access to the highest concentrations of environmental lead. It is necessary that the farmers concerned follow a farm-specific management regime which takes into account the particular lead-related characteristics of their holdings with a view to minimising the intake of lead by their animals.
5. The IAG considers that the characteristics of the local environment are such that farmers generally should take care to follow a regime of grazing, watering, etc. which is designed to minimise the intake of lead by their animals.
6. The IAG considers that farmers should be given the necessary information and advice by the relevant agencies in relation to both (7) and (8) above.
7. As with human health, the IAG considers that there is a need to periodically monitor animal health. It is particularly important that herdowners and their veterinary practitioners make available for examination by the Regional Veterinary Laboratory (RVL) any animals suspected of having died from lead poisoning.

.2.3 *Food Safety*

1. The IAG considers that food produced in the area is generally safe.
2. Lead concentrations within bulk milk samples tested in the course of the investigation were all well within the maximum permitted concentration for human consumption.
3. Lead concentrations in the meat (muscle) samples tested in the course of the investigation were well within the permitted concentrations for human consumption.
4. Liver and kidney, samples from animals from a small number of farms showed lead concentrations in excess of the permitted maximum. This will require continued monitoring.

5. Three leafy vegetable samples from a particular location within the area were found to exceed the statutory limit for lead. Further sampling must be done before firm conclusions can be drawn from this result. All other samples were below the limit.
6. Drinking water for human consumption in the area tested as part of the investigation was in compliance with the Drinking Water Regulations.

.2.4 Soil, Herbage, Fodder and Drinking Water (for animals)

1. The extent to which soils of the Silvermines areas contain excessive concentrations of heavy metals, principally lead and zinc, but also cadmium, copper and arsenic has been quantified.
2. The quantity of soil lead in the Silvermines school yard gives immediate cause for concern.
3. Soil lead concentrations in about one third of the area were considered to be elevated to an extent which would warrant implementation of appropriate management regimes to minimise lead intake.
4. Tests on the grazed herbage (grass), silage, hay and animal drinking water (excluding stream sediment) samples taken in the course of the investigation did not indicate a risk to animal health.
5. Phosphorus levels are low and lime requirements are high for the agricultural soils surveyed compared with the average for Tipperary.
6. Elevated levels of soil cadmium and arsenic were noted particularly in the Gortmore TMF.

.2.5 The Local Environment

1. Lead is a major geological element in the environment of the Silvermines area and lead mining has for centuries been a feature of local economic activity. Living and working safely in the area means managing on an ongoing basis the presence of lead and its influence. This requires not alone personal responsibility and commitment but community consciousness and commitment and, where necessary, the support and assistance of the relevant agencies.
2. Historical, geological and geochemical data and sampling and testing undertaken as part of the investigation have shown significant concentrations of lead in the soil and underlying rock structures across most of the area encompassed by the investigation and have highlighted high lead concentrations at certain locations.
3. Former mine workings, such as those at Gortmore, Shallee, Garryard and the area above Silvermines village, are among the most visible reminders of the presence of lead in the locality. High concentrations of lead are not however confined to these sites.
4. Elevated concentrations of lead have been found in surface water and sediments in the Yellow River catchment.
5. The results of testing carried out in relation to both surface water and sediment indicate that significant concentrations of lead can be distributed within the area by water flow, particularly when sediment is disturbed by dredging, flooding or animals.
6. The IAG noted that there was no evidence of any significant lead dust-blow affecting the area during the period of the investigation. Four out of 124 results exceeded the TA Luft standard.

.2.6 Mine Workings

1. The IAG considers that the present condition of mining-related sites, most notably at Gortmore, Shallee, Garryard and the area above Silvermines village, is not acceptable from the point of view of protecting human and animal health in the Silvermines locality. Measures must be taken without further delay at these and other sites in the area to manage the risk to health which they pose. Such measures will require a purposeful and sustained commitment by all concerned over the short, medium and longer terms.
2. It is the view of the IAG that it is essential that action be taken according to a clear timetable of the shortest possible duration. It is equally important in the view of the IAG that the people of the area be provided with insight into such action and with an opportunity to make appropriate input. Technical assessments need to be undertaken to define the necessary risk management measures. Issues of land and mineral ownership will also need to be clarified.

3. Insofar as the Gortmore TMF is concerned, the IAG considers that the position remains highly unsatisfactory. The EPA in January, 1999 concluded that the facility represents a perpetual risk to human health and the environment which requires structured, comprehensive, active and continued management involving a commitment of significant resources. That report contained a number of recommendations for action by EPA and others. The County Council has made a sustained and determined effort to have Mogul address their responsibilities in this regard. Mogul undertook certain measures in 1999 to promote grass cover on bare (un-grassed) areas of the TMF and is committed to continuing further work in 2000. However, the IAG believes that detailed specialist studies are required to identify methods of establishing grass or other ground cover material on the TMF and to determine the appropriate rehabilitation measures to ensure its structural and chemical stability and to upgrade its biological status in the longer term. This scientific study is being undertaken by the DMNR (see Appendix 8.1) which, under Clause K of the State Mining Lease, can require the lessee, Mogul of Ireland Ltd., to rectify the lands associated with the mining activity. Unless and until the measures necessary to ensure structural and chemical stability and to establish ground cover are implemented in full, the IAG considers that the threat posed by the facility to human and animal health in the area will not have been adequately addressed. The IAG further considers it essential that there be by end-December, 2000 a definitive plan for the rehabilitation and long-term management of the Gortmore TMF.
4. Pending implementation of the measures referred to above, it is essential that the emergency plan be implemented in full, without any further delay.
5. The IAG considers that the mine workings at Gortmore, Shallee, Garryard, and the old Ballygowan mine in the vicinity of the Silvermines school will not be suitable for agricultural activity (animal grazing) and uncontrolled access by children in the foreseeable future.

.2.7 *The Inter-Agency Approach*

1. The IAG, based on its experience in this instance, consider that the inter-agency approach is an effective model for addressing in a comprehensive and timely manner issues of public and animal health and environmental concern where circumstances warrant such an approach. The benefits of an inter-agency approach have clearly exceeded what would have been generated by independent, individual studies undertaken by each participating agency. The process has also allowed the development of further necessary environmental expertise within the State. Such an approach, however, necessitates a substantial and concentrated commitment of resources by the participating agencies for the duration of any such exercise. Given that such an inter-agency approach, where appropriate, is envisaged by the protocol established in the course of the Askeaton Animal Health Investigations, consideration must be given making contingency for such essentially unplanned exercises within the resource base and work programmes of the agencies in question.

.2.8 *Implementation*

1. The IAG has concluded that there is a clear need to co-ordinate the implementations of the recommendations contained in this report. An implementation IAG should be established and given the necessary mandate. It should have regard to appropriate local views and needs, and to guidelines on the management of lead in the environment. It should also maintain a dialogue with the people of the area in relation to their concerns and the progress of its work. The implementation of the recommendations contained in this report should constitute an integrated action plan for the area. The necessary resources should be made available to each agency in discharging its particular responsibilities.

.3 RECOMMENDATIONS

.3.1 *Human Health*

1. The school play area in Silvermines village should be resurfaced immediately. It should then be fenced in to define a safe play area.
2. Children should be discouraged from accessing other areas of high lead content.
3. A programme of annual blood lead surveillance should be implemented for pre-school and school children in the Silvermines area. The results of this programme, which will commence in Autumn, 2000, should be reviewed after 2-3 years of testing.

4. Internal and external environmental sampling should be carried out in Silvermines village on a once-off basis in Autumn, 2000 for the purpose of providing additional insight into the presence and influence of lead in this particular location and thereby a more informed basis for future precautionary measures relating to human health within this population centre.
5. Steps must be taken to enhance and maintain public awareness of the presence and influence of lead across the Silvermines area.
6. The active involvement and assistance of the local community, and community-based organisations, should be secured in addressing lead exposure and specific prevention strategies through education on:
    - basic hand-washing practices with a special focus on pregnant women and the parents of young families;
    - preparation of locally grown fruit and vegetables for domestic consumption;
    - the importance of adequate dietary intake of calcium, iron and vitamin C;
    - dust minimisation in the home.

.3.2 *Animal Health*

1. Further evaluation will be required on some farms with elevated blood or tissue lead concentrations in order to identify environmental and other factors contributing to lead intake. A management system designed to minimise lead intake by food animals should be drawn up by DAFRD and Teagasc for these farms
2. Details of a generally applicable regime of grazing and other farm management controls (including access to streams, etc.), designed to minimise lead intake by animals, should be made available by Teagasc to all farmers in the area.
3. In the case of calves, which have a higher susceptibility to lead poisoning, particular attention should be paid to the implementation of farm management controls given in this report.
4. A targeted programme of blood-sampling and analysis should continue in the area in order to more fully assess the impact of environmental lead on animal health. This will be subject to ongoing review.
5. In order to assist in the accurate identification of cases, herdowners in the area and their veterinary practitioners should make available to the RVL of DAFRD for laboratory examination animals which are suspected of having died from lead poisoning.
6. As in the case of farm animals, care should also be taken to protect the health of domestic and companion animals.

.3.3 *Food Safety*

1. Water used for human consumption should only be taken from supplies which comply with the standards laid down in the Drinking Water Regulations.
2. The following steps should be taken in the preparation for human consumption of all locally-grown fruit and vegetables in order to reduce dietary exposure to lead:
    - thoroughly wash all fruit and vegetables in running water of drinking quality;
    - peel potatoes prior to cooking;
    - remove the outer leaves of leafy vegetables prior to washing and consumption.
3. A further programme of fruit and vegetable sampling should be undertaken - the duration of which should be determined by reference to the results of testing as they become available.
4. Milk produced from any dairy herd in the area which was not in production during the 1999 round of milk sampling should be sampled and tested when production resumes.
5. Livers or kidneys with lead or cadmium concentrations above those permitted for human consumption should be excluded from the food chain.
6. Monitoring of lead concentrations in the livers and kidneys of all slaughtered animals from farms in the area - using the CMMS system for animal / herd identification or suitable alternative - should continue until end-2000 – at which stage the need for further monitoring will be reviewed.

7. Tissue monitoring may need to be re-introduced in the future in the event of incidents giving rise to excess lead concentrations in the area, e.g. significant dust-blows or flooding.
8. Cadmium concentrations should be monitored in tissues (kidney) of animals from farms on which high soil cadmium concentrations have been detected.

.3.4 Soils, Herbage, Fodder & Animal Drinking Water (for animals)

1. Farmers in the area should have soils analysed to establish lime requirement and nutrient status and soils should be limed to pH 6.5 if necessary and phosphate applied as required. Nitrogen should be applied to maintain a dense and healthy grass sward.
2. Farmers should refer to soil lead maps to determine the lead status of their soils.
3. Soils, particularly on farms showing elevated soil lead concentrations, should be disturbed as little as possible. This entails avoiding poaching by animals and damage to sward by machinery.
4. Animals should not be allowed to ingest herbage which has been heavily contaminated by soil - either by poaching, flooding or wind-blow from tailings facilities.
5. Where re-seeding is required, part of the area should first be tested to ensure that re-growth does occur. Late flowering, preferably diploid ryegrass varieties which best ensure a dense sward, should be used.
6. Farmers should not spread sediment from drainage works on their pastures. Spoil from drainage and dredging works on the Yellow river and its tributaries should be fenced off and not spread over pastures. Pastures subject to flooding in the Yellow river catchment should not be grazed while obviously contaminated with sediments.
7. Animals should not be allowed direct access to water-courses. Drinking water for animals should be extracted from streams (e.g. by pump).

.3.5 Rivers, Streams, Sediment & Dust Monitoring

1. A programme of works to rehabilitate and manage the Garryard mine complex and water discharges from the site should be drawn up and implemented.
2. Biological and physico-chemical monitoring should be continued on the Yellow and Kilmastulla rivers. In addition, further water sampling upstream of Silvermines village should be undertaken. Sampling in the area should be reviewed on an annual basis.
3. To avoid the disturbance of sediments, the rivers and streams in the Yellow river catchment area should not be used for recreational purposes.
4. In the short term, the current dust monitoring programme should be continued until the risk of dust blow has been eliminated.
5. The emergency plan to prevent dust-blows should be implemented in full.
6. A contingency plan should be prepared and available for implementation in the event of a major dust-blow incident.

.3.6 Mine Workings

1. The settlement pond and tailings lagoon at Garryard, the unvegetated tailings at Shallee, and the Gortmore TMF, should all be securely fenced off until definitive rehabilitation has taken place.
2. Mogul will manage the Gortmore TMF under the emergency plan agreed with TNRCC, pending final rehabilitation.
3. Management plans for each historic mine site in the area should be formulated by end-2000 by consultants employed by DMNR. Agreement on and implementation of management and rehabilitation plans should accord with clear timetables and should be completed within the shortest possible timeframes. If the necessary co-operation is not forthcoming from all concerned, the relevant agencies should have recourse to their statutory powers or to legal remedy.
4. Management plans should be formulated and implemented for other sites with elevated lead concentrations in the Silvermines area which may be identified.

.3.7 Implementation of Recommendations

1. An implementation group should be established and mandated to ensure that the recommendations contained in this report are implemented. Its composition should include all of the relevant agencies. It should have regard to appropriate local views and needs, and to guidelines on the management of lead in the environment. It should also maintain a dialogue with the people of the area in relation to their concerns and the progress of its work. It should meet at regular intervals with the local community.
2. As a matter of priority, an expert group - to include international experts - should be established to formulate guidelines applicable to Ireland on the management of lead in the environment. The conclusions of this group, which should be asked to complete its work within a short timeframe, should be available to, and should inform the work of, the implementation group in giving effect to the recommendations contained in this report.

GLOSSARY OF TERMS

Inter-Agency Group (IAG), comprising:

DAFRD: Department of Agriculture, Food, and Rural Development.

DMNR: Department of the Marine and Natural Resources.

EPA: Environmental Protection Agency.

TEAGASC: Agricultural Advisory and Research Service.

TNRCC: Tipperary (NR) County Council.

MWHB: Mid-Western Health Board.

Definitions:

Prevalence: The number of cases of a particular condition arising in a given population at a specified point in time.

Screening: The presumptive identification of a disease or condition by the application of tests, examinations, or other procedures which can be applied rapidly. Screening tests differentiate between apparently well people who probably have a disease or condition and those who probably do not. A screening test is not intended to be diagnostic.

Abatement: any set of measures designed to permanently eliminate hazards.

Pica: an abnormal tendency to mouth or attempt to consume non-food items such as paint chips or soil **.**

Bioavailability: the proportion of a substance which is absorbed into the blood stream and is biologically active.

Farm A: Laboratory-confirmed multi-case outbreak at Shallee 1999.

Farm B: Multi-case outbreak (calves) at Shallee 1998 and April, 2000.

TMF: Tailings Management Facility.

Toxic Effect (biological): A toxic effect is where certain animal species are totally absent which would normally be present even in cases of organic pollution.

Conversion Table for Units	
1 µg/dl	= 0.0483 µmol/l
1 µmol/l	= 20.70 µg/dl
1 mg/kg	= 4.828 µmol/kg
1 µmol/kg	= 0.21 mg/kg
1 ppm	= 1 mg/kg

LIST OF MAPS

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[*] The shaded zone on Map 2 indicates the broad area within which environmental, human, animal, and crop studies were undertaken. The ‘Study Area Boundary’, outlined in red on the following maps, identifies the limit of the farm investigations.