MANAGEMENT AND REHABILITATION OF THE SILVERMINES AREA

PHASE I REPORT:

REVIEW OF AVAILABLE INFORMATION

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

APPENDIX A **RFERENCES AND BIBLIOGRAPHY**
APPENDIX B **MINUTES OF MEETING**
APPENDIX C **TABLES – VEGETATION AND HABITATS**
APPENDIX D **SAMPLING AND TESTING PROTOCOLS**

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SUMMARY

MANAGEMENT & REHABILITATION OFTHE SILVERMINES AREA PHASE I REPORT: REVIEW OF AVAILABLE INFORMATION

This report is on Phase I of the study for the management and rehabilitation of the Silvermines area, and is concerned with the review of available information to define Phase II. It is an internal progress report to the Department of Marine and Natural Resources, not for public distribution, and will be superseded by the final design report to be issued in July 2001. Information will be added and corrections made at that stage.

The Phase I study of available information included a necessary site inspection. This inspection was limited by Foot and Mouth restrictions, and it was not possible to complete certain activities or to visit certain areas. It was not possible, for example, to hold the workshop and group site visit, or to view the subsidence areas. Nevertheless, it is considered that the information gathered in Phase I has been sufficient for the design of Phase II, which will include visits to the omitted areas.

INTRODUCTION

The Silvermines area of County Tipperary has been mined for over one thousand years, for lead, zinc, copper, baryte and sulphur. The last mine, Magcobar, closed in 1993. The mining has resulted in undermining and surface subsidence, the excavation of open-pits, the construction of large waste dumps and tailings dams and the presence of derelict surface structures. Figure 1 is an annotated orthophoto showing the main features of the study area. The yellow outline represents the extent of the area.

The mine tailings, the rock waste and other process waste from mining contain heavy metals, which are mobilised after heavy rain, entering the streams. In the past, the tailings impoundments have also produced severe dust blows, with the wind-blown particles containing heavy metals. The metal of most concern has been lead, and there have been cattle deaths attributed to lead poisoning. It is primarily these deaths which have alerted the authorities to the need to undertake closure and rehabilitation measures to reduce the risk to human health and safety, and to the environment. There are, however, other pollutants and other problems such as mining subsidence associated with the Silvermines area which require consideration. These will be included in the present investigation.

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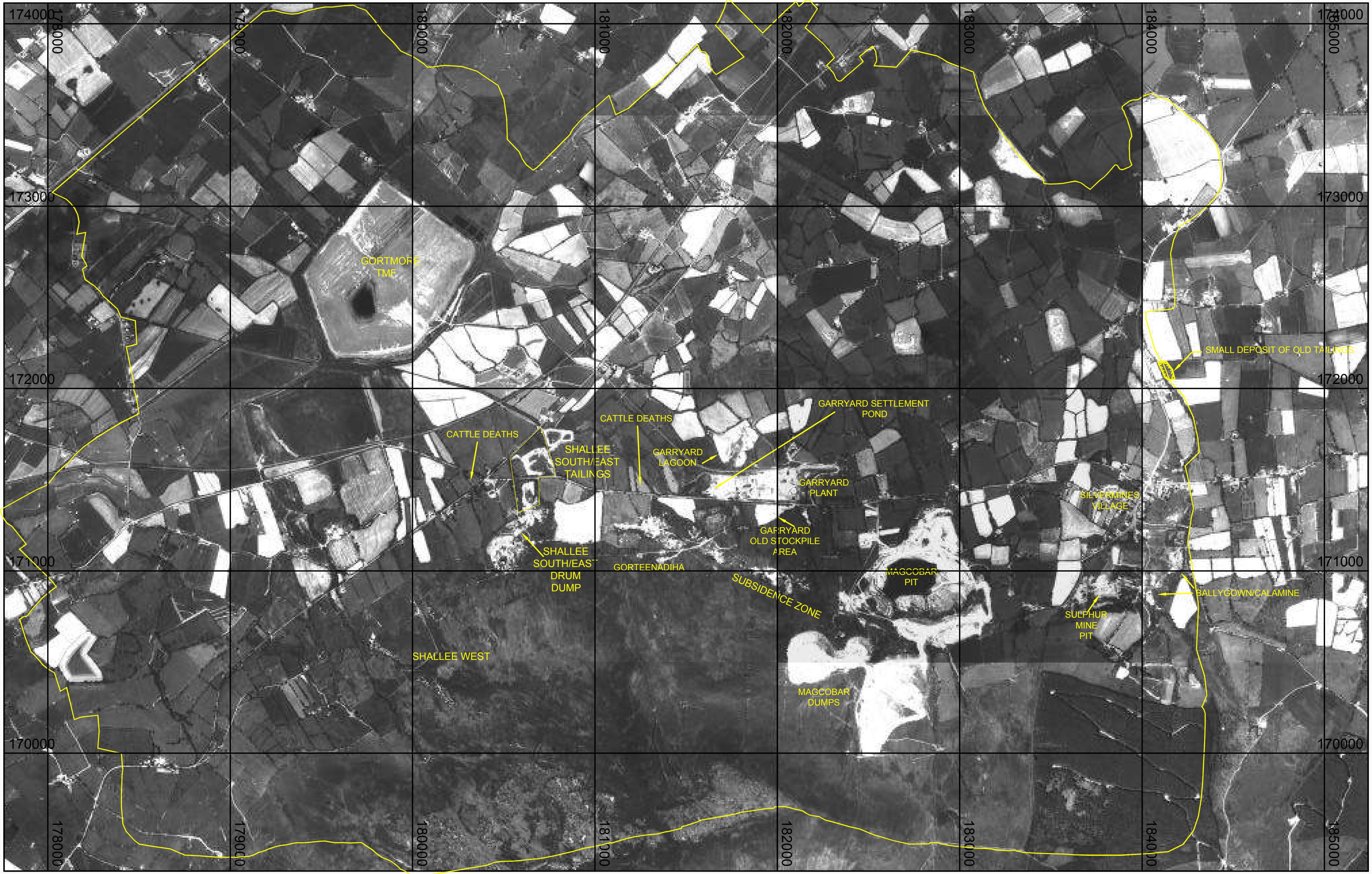

April 2002	PROJ. No: U1606	SILVERMINES	Not to scale
SRK Consulting Engineers and Scientists		THE STUDY AREA	Fig 1

A number of studies have been carried out to investigate the problems and, in 2001, the Department of Marine and Natural Resources appointed SRK Consulting to prepare conceptual designs for the management and rehabilitation of the Silvermines region, over an area of about 2,300 ha. This design was to include five specific sites identified as requiring treatment:

- *Gortmore tailings management facility (GTMF)*
- *Tailings at Shallee*
- *Lagoon and settlement pond at Garryard*
- *Ballygown area and ground to the south of Silvermines village*
- *Magcobar pit and waste dumps*

The work was to include any other sites within the study area requiring remediation. Although particular problem areas were identified, it was recognised by all concerned with the study that the Silvermines area must be dealt with as a whole, because the problems are linked.

THE STUDY

The study was to be carried out in three stages:

- *Phase I, review of available information, to be completed in April 2001*
- *Phase II, site investigation, to be completed in June 2001*
- *Phase III, conceptual design of selected options, to be completed in July 2001*

This report on the Phase I study is concerned with the review of the large amount of documentary information, the identification of gaps in the data, the identification of potential remedial measures, and the definition of the work required for Phase II, the site investigation.

Phase I is concerned with the impacts of the mining, but this summary report will concentrate on the atmospheric, soil and water pollution, as the critical and most problematic issues. Other impacts, such as the visual impact and mining heritage, will be addressed in Phase II.

THE INFORMATION

The available information includes mine records and technical mine reports, the reports of research work on the Silvermines area carried out at universities and technical institutions and the results of studies carried out in response to the cattle deaths. Many of the documents provide important and relevant information, but the key recent reports are:

- *Characterisation study of the Silvermines area, June 2000, by Natural Resource Consultants.*

- *Report of the investigation into the presence and influence of lead in the Silvermines area of County Tipperary, June 2000, Inter-Agency Group (IAG) to the Department of Agriculture, Food and Rural Development*

In addition, SRK held discussions with many interested and affected parties, who provided useful background information and additional documents. Others will be met during Phase II.

The review was supplemented by a three day site inspection by SRK engineers and scientists, all of whom had some previous familiarity with the area.

Information will continue to be collected and reviewed during the Phase II study and, in particular, the Silvermines research work carried out by staff at the Sligo Institute of Technology will be further investigated.

PUBLIC CONSULTATION

As part of the Phase I study, it had been intended that a large workshop and site visit would be held in Silvermines, but this was prevented by foot and mouth controls. Instead, a meeting with the Agencies was held in Dublin and a meeting with local Silvermines representatives was held in Nenagh. It is intended that a report-back meeting will be held at the end of the project.

The meetings were intended to disseminate information on the nature of the study to be carried out by SRK, to gather relevant technical information, and to solicit an expression of the concerns of the interested and affected parties. It is believed that these objectives were achieved.

The Agencies were in agreement with the programme, and offered whatever assistance they could provide. The local representatives emphasised that the main local concerns are dust blow from the Gortmore tailings management facility and the pollution of streams by material washed from dumps at Shallee mine and Mogul plant areas.

POLLUTION POTENTIAL

In general, the information available from the literature and from previous investigations provides a reasonable record of the ecology, of the mining and of the impacts of the mining.

The sulphide mineralisation in the Silvermines area can result in the release of metals and elevated salts from the oxidation of the sulphides and the dissolution of the metals, and this has been the main source of pollution by lead, zinc and cadmium. The highest potential for metal release is in the infill and breccia mineralisation, particularly in the vicinity of Mogul Mine, which also has the highest potential for acid generation. The host rock is predominantly carbonate, neutralising the acid potential, and resulting in the precipitation of metals as carbonates, hydroxides or oxides.

The release of the metals and dissolved salts can be by natural erosion and leaching, but the mining has provided conditions where the underground workings, the tailings impoundments and the waste dumps give the opportunity for the large-scale discharge of particulate metals and leachates (metals and salts in solution). The extent to which this has occurred is documented in various reports, including the IAG report of 2000. The main sources of leachates are the various tailings impoundments, waste dumps and effluent ponds. There have also been significant discharges of particulate material containing heavy metals from these areas. These discharges exist mainly as sediments in the streams and rivers in the vicinity of the mines and, to a lesser extent on adjacent fields, from dust blow, stream dredging and surface sheet wash.

SUFFICIENCY OF PREVIOUS SOIL AND WATER TESTING

The selection of the optimum solutions for the conceptual design of the remediation depends on the adequacy of the data. The chemical data, particularly, must be sufficient, but this does not imply that an exhaustive programme of testing is required for the conceptual design. The requirements are:

(a) Identification of the important pollutants and their sources
(b) Determination of the method of mobilisation and transportation
(c) Confirmation of the destination and effect of the pollutants.

It is also important to recognise that elevated levels of metals will occur naturally, therefore background levels prior to mining would have been above normal levels. The elements previously tested do not include certain components which may be of importance. These include mercury and cyanide (which was used in small quantities in the Mogul process), and it is proposed that additional testing be carried out to determine the levels of these elements.

Soil testing

Soil analyses for lead were undertaken in 1963 by Mogul as part of their mineral exploration programme prior to mining. Elevated levels were found round Silvermines village, along the foot of the Silvermines mountain, around Shallee and Gortmore and in the north around Ernagh. Mogul carried out further soil tests in 1976, 1978 and 1981. After the dust blows in 1985, further soil and herbage samples were tested.

The most recent soil tests were carried out for the IAG study, when samples were collected on a grid within an area extending 3km north and 2km south of a line from Silvermines village to Kilnacranna. The elements tested were arsenic, lead, zinc, copper, cadmium, pH and loss on ignition (organic matter content). The results of the IAG study confirmed that the average agricultural soil in the area had significantly elevated lead, zinc and cadmium that allowed some possibility of impact on crops or animals. Approximately one fifth of the 223 soil samples in the particular survey had lead values of 1000mg/kg which has been suggested as a threshold value below which toxicity problems would not normally be expected in animals

(IAG report page 65). The IAG results (map 1) suggest that elevated metal contents are directly associated with the ore zones, mine processing areas and the soils adjacent to the rivers draining from the mining area. The general agricultural soils away from the rivers show relatively low values.

As part of specific future rehabilitation or management programmes, there may be a need for additional sampling at selected positions, particularly adjacent to streams and drainage channels, where metals may have been deposited during floods or after dredging.

Stream water testing

Surface water quality has been tested for thirty years, but the most useful detailed information comes from testing since 1990. Since 1971, all monitoring stations on the Yellow River have recorded high heavy metals. The stream draining the Garryard mine complex had the poorest water quality. There is a significant dilution effect in the Kilmastulla River, and ***the quality of the water leaving the study area in the Kilmastulla river is within the EU required limits apart from iron, which is only marginally outside the limit.***

The available information is useful, but there is a need for more upstream sampling, to identify the contributions from specific small streams to the pollution levels in the larger water courses.

Stream sediment testing

There is no information on the testing of stream sediments prior to 1999. In 1999, testing for the IAG report and by the EPA revealed elevated metal concentrations throughout the area, with particularly high levels in a small stream draining the Garryard settlement pond. Metals were at elevated levels both upstream and downstream of the Shallee mine area.

In summary, stream sediments contain elevated metal concentrations in the vicinity of former mine workings, although elevated values are also found elsewhere.

Groundwater testing

There is very little information on groundwater quality or flow characteristics. Most data comes from the investigation at Magcobar, where 17 boreholes were drilled as part of the investigation for the proposed use of the pit as a landfill. It is probable that contaminants from the various mining activities have entered the groundwater system, but this requires substantiation.

Additional investigations of groundwater quality are required for confirmation of the groundwater conditions. The results of the investigation may result in the design of measures to augment the conceptual remedial works developed for the surface features. The specific requirements for additional drilling and testing will be assessed during Phase II.

HAZARD IDENTIFICATION

The preliminary list of hazards is as follows:

- *Stream and pond pollution, by water and sediments from mine workings and mine waste.*
- *Groundwater pollution from mine workings and mine waste.*
- *Land contamination from mine waste, from dust blow, from dredging of stream sediments, and from ground surface flows after heavy rain.*
- *Atmospheric pollution by dust from tailings impoundments, mainly Gortmore TMF.*
- *Unsafe shafts, mine workings, cavities and surface subsidence.*
- *Water-filled pits and lagoons at Magcobar, Garryard, Gortmore and Shallee.*
- *Abandoned and unsafe surface structures at Ballygown, Magcobar, Garryard, Shallee.*
- *Potential instability of tailings impoundments and waste dumps at Shallee and Gortmore.*

The potential environmental impact of a hazard will be a function of the nature of the hazard, possible future changes, the means by which the hazard can impact on the environment (the pathway) and the sensitivity of the receptor. This will be assessed using a risk based approach in Phase II.

POSSIBLE REMEDIAL OPTIONS

At this Phase I stage of the study, the possible options for the various sites and the site as a whole have been identified. The preferred options will be selected after Phase II, the site investigation, in consultation with DMNR. It is not feasible in this summary to describe the numerous options, but the key options for the main problems will be:

- *The establishment of a permanent, low-maintenance cover for the Gortmore TMF and the control or treatment of polluted discharges from the impoundment.*
- *Stabilisation of the Shallee tailings and stabilisation or removal of dumped chemical wastes at Shallee mine, as part of the mine rehabilitation.*
- *Complete draining and rehabilitation of the Garryard settlement pond and lagoon, or the establishment of a wetland or other treatment system.*
- *Garryard (Mogul) underground mine, prevention of access to surface subsidence areas, interception and treatment of seepage.*
- *Mogul waste dump on opposite side of road from plant, interception and treatment of seepage, removal or encapsulation of waste.*
- *Ballygown area and area to the south of Silvermines village, reshaping, treatment of seepage, making safe of mine and shafts, preservation of historic structures.*
- *Magcobar mine, prevention of pit access or making safe of pit for recreational use, minor reshaping and stabilising of dumps and promotion of vegetation, interception and treatment of seepage.*

All the measures must be acceptable to interested and affected parties, and comply with an overall policy for water discharge quality and for land-use.

THE PHASE II STUDY

The Phase II study will consist of (a) the sampling and testing of water and soils, (b) the site assessment from the information gathered in Phase I and Phase II in terms of safety, pollution, water, ecology, industrial archaeology and surface structures, (c) the review of the management and rehabilitation options and (d) in consultation with DMNR, the selection of the preferred options. The drilling requirements and timing of drilling will be discussed with DMNR. The mining heritage has not yet been considered, and will be studied by an industrial archaeologist.

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May 2001

MANAGEMENT AND REHABILITATION OF THE SILVERMINES AREA

PHASE I REPORT: REVIEW OF AVAILABLE INFORMATION

1 INTRODUCTION

1.1 General

The Silvermines area has been mined for more than one thousand years, and mining finally ceased in 1993. The Department of Marine and Natural Resources (DMNR) intends to implement closure and rehabilitation measures over the area of approximately 2,300ha, and has appointed SRK Consulting to prepare a conceptual design for this purpose. The work is to be carried out in three phases, and this document reports on Phase I - Review of the available information. The subsequent phases will comprise the fieldwork and the conceptual closure and rehabilitation design. The Phase I report will be superseded by the subsequent final report.

1.2 Terms of reference

The terms of reference in a DMNR letter of September 1st, 2000, outlined the following objectives for the work:

1. Preparation of management plans and/or rehabilitation plans for

   - TMF at Gortmore (GTMF);
   - Tailings at Shallee;
   - Lagoon and Settlement pond at Garryard;
   - Ballygown area and ground to the south of Silvermines village; and
   - Any other areas which may be identified during the consultancy as requiring the same.

2. Provision of cost and time-scale for implementing these plans.
3. Consultation with the public and agencies as part of the study and preparation of plans.

4. Assistance and advice to the Department in presenting such plans to the agencies and owners responsible for carrying out and supervising the plans and to the local population.

The consultants are required to identify and cost the necessary works to rehabilitate and/or manage the local environment in relation to mining-related features:

- Openings, vent raises, shafts and declines;
- Mine buildings;
- Tailings;
- Stream sediments enriched in heavy metals;
- Waste rock and other mining residues;
- Scrapped equipment, metals, containers or chemicals used in former mining operations;
- Subsidence, whether mining or natural; and
- Hydrogeological impacts.

The consultants are required to present separately the subset of these work plans which corresponds to works which Mogul of Ireland might be asked to carry out under Clause K of their State Mining Lease.

1.3 The study

In summary, the work comprises:

PHASE I

- A review of the very extensive available information.
- Consultation with Interested and Affected Parties.
- Identification of the possible rehabilitation options.

PHASE II

- Site sampling and testing of water and soils to supplement and confirm the available information.
- Compilation of a complete photographic record and inventory of surface structures.

- Preparation of an assessment of pollution, water, ecology, industrial archaeology, and surface structures.
- Review of the rehabilitation options
- Recommendations

PHASE III

- Conceptual design of the selected rehabilitation options.
- Costing of the selected options
- Production of a final report.

1.4 Information available

The documents and plans examined during the Phase I study are tabulated in Appendix A. **Where documents are referred to in the text of this report, the superscript number refers to the identifying reference in Appendix A.**

The available information is extensive, and there have been two recent studies which are of very direct relevance to the study:

- In 2000, Natural Resource Consultants of Sligo were appointed by DMNR to carry out an Initial Characterisation Study of the Silvermines area[86], and the report was issued in May 2000.

- The Department of Agriculture, Food & Rural Development (DAFRD) "Report of the Investigation into the Presence and Influence of Lead in the Silvermines area of County Tipperary" (the IAG Report[87]) was published in June 2000. It was based on work carried out under the guidance of an Inter-Agency Group (IAG) in response to local concerns about cattle deaths from lead poisoning and dust blows from the Gortmore Tailings Management Facility (GTMF).

The characterisation study has provided invaluable background information, and the IAG Report contains the processed results of extensive sampling and testing, as well as guidance for future studies.

The IAG Report made 39 recommendations, including the recommendation that an Expert Group should be established to formulate guidelines applicable to Ireland on the management of lead in the environment. This Group has been formed in 2001, and is active in the fulfilment of this task.

Other documents and information sources have been identified during Phase I but have not yet been obtained. These will be consulted during the Phase II study.

1.5 Identification of sites within the study area

Section 1.2 differentiated between four mine and disposal areas which were tentatively considered to be units in terms of their location, extent and remediation options. There are various different features within these areas and outside them and, to avoid confusion, Table 1.1 gives the names which will be used in this report, generally working from East to West.

The names used in the report for important features without specific names in the different areas are also given in Table 1.1.

Table 1.1 : Site Identifications

AREA	NAME USED IN THIS REPORT	SITES INCLUDED	NAMES USED FOR INDIVIDUAL STRUCTURES
A	**BALLYGOWN**	Ballygown, Calamine, Sulphur, and Knockanroe mines south of Silvermines village, playing fields	Sulphur mine Drainage adit Waeltz plant site
B	**MAGCOBAR**	Magcobar pit, underground workings, dumps and surface structures	Dumps A, B, C, D, E
C	**GARRYARD (MOGUL)**	Garryard settling pond and lagoon, Mogul plant, Mogul and Ballynoe underground workings, Mogul stockpile area, subsidence zones	Garryard settlement pond Garryard Tailings lagoon Garryard old stockpile area Subsidence zone
D	**GORTEENADIHA**	Gorteenadiha mine including waste dumps between Magcobar and Shallee	Open-pits Spoil and process areas
E	**SHALLEE SOUTH/EAST**	Shallee South and East mines, surface structures, drum dump and tailings impoundment	Shallee drum dump Shallee north tailings (north of road). Shallee south tailings
F	**SHALLEE WEST**	The shallow opencast workings at Shallee West (also known as Shallee White)	
G	**GORTMORE TAILINGS MANAGEMENT FACITILITY (GTMF)**	The Gortmore tailings impoundment and ponds	Gortmore tailings pool Gortmore return water ponds

Rivers, streams, soils and isolated waste deposits will be considered outside these key areas, and identified separately.

2 THE SITE INVESTIGATION

An inspection of most of the mine sites has been completed and an inventory of surface structures and a photographic record completed. The restrictions on movement imposed in order to prevent the spread of Foot and Mouth disease (FMD) limited the investigation to non-farm areas and areas without cattle or sheep.

2.1 Site inspection and photographic record

The site was inspected on foot by three team members over a period of three days, from April 10 to April 12. A limited photographic record was made with a digital camera and SLR camera. This record was extended on subsequent visits as the Foot and Mouth restrictions allowed and will be reproduced in the Phase II report.

2.2 Surface structures

The surface structures were noted and briefly described, including all information relevant to the proposed rehabilitation. The structures included buildings, mine workings, pits, waste dumps and roads.

A preliminary location of watercourses and springs was confirmed during the site inspection but was limited, due to lack of access to farm areas. Areas of surface subsidence were inspected where accessible, but the area of Gorteenadiha and Mogul workings could not be accessed due to restrictions.

3 PUBLIC CONSULTATION

3.1 The general consultation procedure

It had originally been intended that a Workshop would be held in Nenagh or Silvermines, to allow Interested and Affected Parties to express any concerns, and to gather relevant information. The Workshop was to have been followed by a site visit. This was not possible because of the FMD restrictions. Instead, a consultation meeting was held with the various Agencies in Dublin, and a further meeting was held with representatives of the Silvermines community in Nenagh. The Minutes of these meetings are in Appendix B. It is intended that there will be a report-back meeting involving a broader audience at the end of the study.

Additional discussions were held with local residents and farmers during the field investigation, and these included a meeting with farmers whose cattle had died of lead poisoning.

The consultations proved valuable, providing information which would not otherwise have been gathered and engendering an understanding of the concerns.

3.2 Meeting with Agency representatives

The meeting was convened by DMNR at their Dublin offices, and included four representatives of the DMNR. The other participants were members of the Silvermines Implementation Committee, from the Mid-Western Health Board, Teagasc, a Local Community Representative, the Department of Agriculture, Food and Rural Development, the Environmental Protection Agency, and the Department of Marine and Natural Resources.

The project terms of reference were described, and the methodology proposed by SRK was presented and approved. Contacts were made for future exchanges of information and co-operation during the fieldwork.

3.3 Meeting with representatives of the Silvermines community

The meeting was organised by SRK at the Abbey Court Hotel, Nenagh, but the seven invitations were made by the local community representative who had attended the Agency meeting.

The nature and extent of the SRK study was explained, and the meeting was opened for discussion. The main concerns were said to be:

- Dust blow from Gortmore TMF
- Pollution from material dumped by Mogul at Shallee Mine and at a site adjacent to the old Mogul plant, but on the other side of the main road.
- The need to preserve the mining heritage of the area.

3.4 Meeting with farmers directly affected by lead poisoning of cattle

As a result of the meeting with local representatives, a further meeting with farmers who had suffered cattle deaths due to lead poisoning was held on the following evening.

The farmers (referred to as Farmers A and B in the IAG report) asserted that the cattle deaths were caused by sediments washed down the streams after heavy rain, and by dust blow from the Gortmore TMF. They expressed the opinion that their problems and concerns were being ignored by the authorities.

4 THE MINING AT SILVERMINES

4.1 Mining history

The mining history is described in detail in the Characterisation Study[86] and is not repeated here except where relevant to the present study. Table 4.1 summarises the mining features at Silvermines. The site locations are shown on Figure 4.1

Table 4.1 : **Mining Areas (from east to west)**

AREA	DESCRIPTION	OPENED	CLOSURE	COMMENT
BALLYGOWN				
1	Calamine (zinc)	19th Century	1951	High concentrations of Pb, Zn and As in soil
2	Calamine(lead)	19th Century	1950's	
3	Sulphur	19th Century	19th Century	
MAGCOBAR				
5	Lead	1963	1982	Relatively low levels of heavy metals recorded
6	Copper	19th Century		
8	Lead	1963	1982	
9	Magcobar barite pit	1963	1993	500m x 300m x 70m deep, water-filled pit & small underground area.
GARRYARD (MOGUL)				
4	Zinc-Lead	1962	1982	High concentrations of Pb, and Zn in soil
GORTEENADIHA				
10	Lead	19/20th Century	Nk	Pb, Cd, Cu, Zn, As, CN in soils
11	Copper	19/20th Century	Nk	
SHALLEE SOUTH/EAST				
12	Lead	19th Century	1958	Proposed Mining and Heritage Centre
13	Lead	19th Century	1958	Pb, Cd and Cu in soils
SHALLEE WEST				
14	Lead	19/20th Century	Nk	Pb, Zn and As in soils

*Nk – not known

4.2 Ballygown

4.2.1 Knockanroe-Ballygown South

Major mine workings, principally for zinc, were excavated at Ballygown and Knockanroe to the south of Silvermines village.

At Ballygown, there are extensive abandoned open pit and underground 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 Ballygown to treat the waste from these previous phases of mining. Zinc oxide production ceased here in 1951. The mineralised zone at Ballygown and Knockanroe 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. Mogul also did some limited mining in the area.

4.2.2 Calamine area

This is geologically an extension of the Ballygown/Knockanroe ore. There is no detailed information available but mining was both open pit and underground as recently as the 1940s. Two small pits are located at the south end of the site and the underground workings are to the north. There is a line of shallow ventilation shafts extending southwards across the main road with an adit entrance about 200m south of the road. It is understood that this was a drainage adit and ferruginous minewater drains from the collapsed adit (Aslibekian, pers. comm. 2001).

The area of workings is about 7Ha and is covered by a range of low spoil heaps, buildings, shafts etc. There are a number of shaft sites indicated on plans but it is difficult to identify most of them. This makes it difficult to assess the safety aspect but it is likely that they have not been backfilled or capped in a formal way. This matter will be further reviewed in Phase II.

4.3 Magcobar

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.

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.

A large amount of waste rock was generated from the open pit and the waste rock dumps form a significant feature for the rehabilitation programme.

4.4 Garryard (Mogul)

Mogul carried out exploration drilling at Knockanroe, Ballynoe, Garryard and at Shallee. The only mining development was at Garryard, where 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. From 1982 to the early 1990's Ennex International continued exploration drilling in order to assess a future deposit. Despite encouraging results, due to low prevailing metal prices all activities had ceased by 1994.

The mine was developed from subcrop below drift overburden on the hillside towards the north under the main road to depths of around 250m below surface. The main access shaft is in the plant site.

The early mined areas have suffered significant collapse which is clearly visible on the hillside. The area could not be visited during the site work due to FMD.

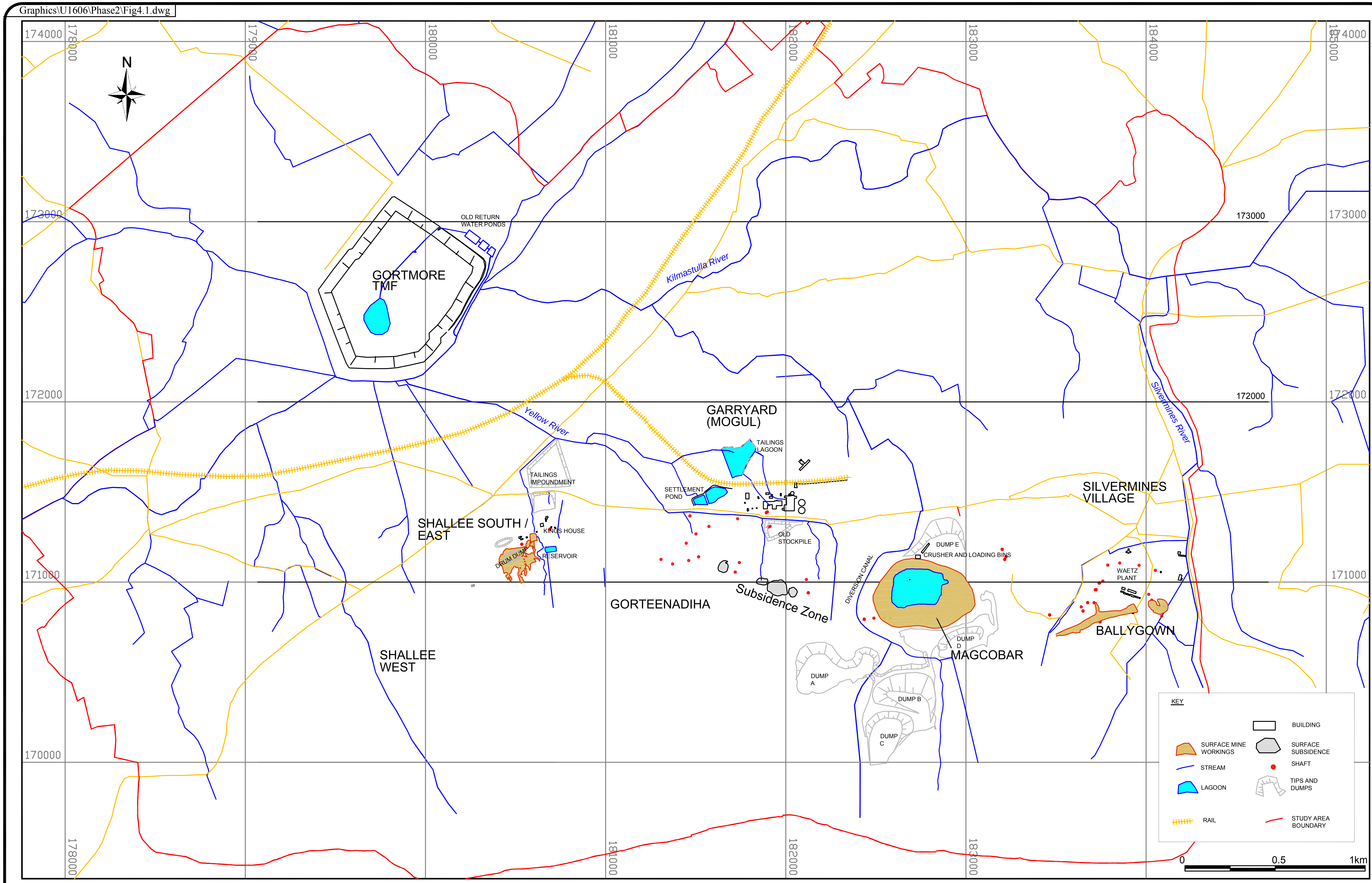
Later working were backfilled with cemented, pyrite rich tailings which limits the potential for collapse. There is a collapse feature adjacent to the road at the entrance to the Magcobar site. The origin of this feature will be considered during the Phase II study.

4.5 Gorteenadiha

The workings at Gorteenadiha are believed to date back to the early 19th century. Veins were worked for lead, copper and silver from surface and several small pits and waste rock dumps occur in the vicinity. This site could not be visited but it is a relatively small area of rubble with some shallow underground workings. They were worked in the 18th and early 19th centuries and probably do not constitute a major hazard today. This will be further investigated

4.6 Shallee mine

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. 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.



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BASE MAP OF SILVERMINES AREA

Fig 4.1

5 SITE CHARACTERIZATION

Site characteristics were initially determined using published maps and plans, aerial photographs and previous reports. In particular, digital information was supplied by K.T. Cullen[107] from the investigation for the IAG report[87]. Following this initial desk study, walk over surveys were conducted, within the limitations of the foot and mouth disease procedures, to ensure the information gathered was a true representation of the site. This section summarises the findings.

5.1 Topography and drainage

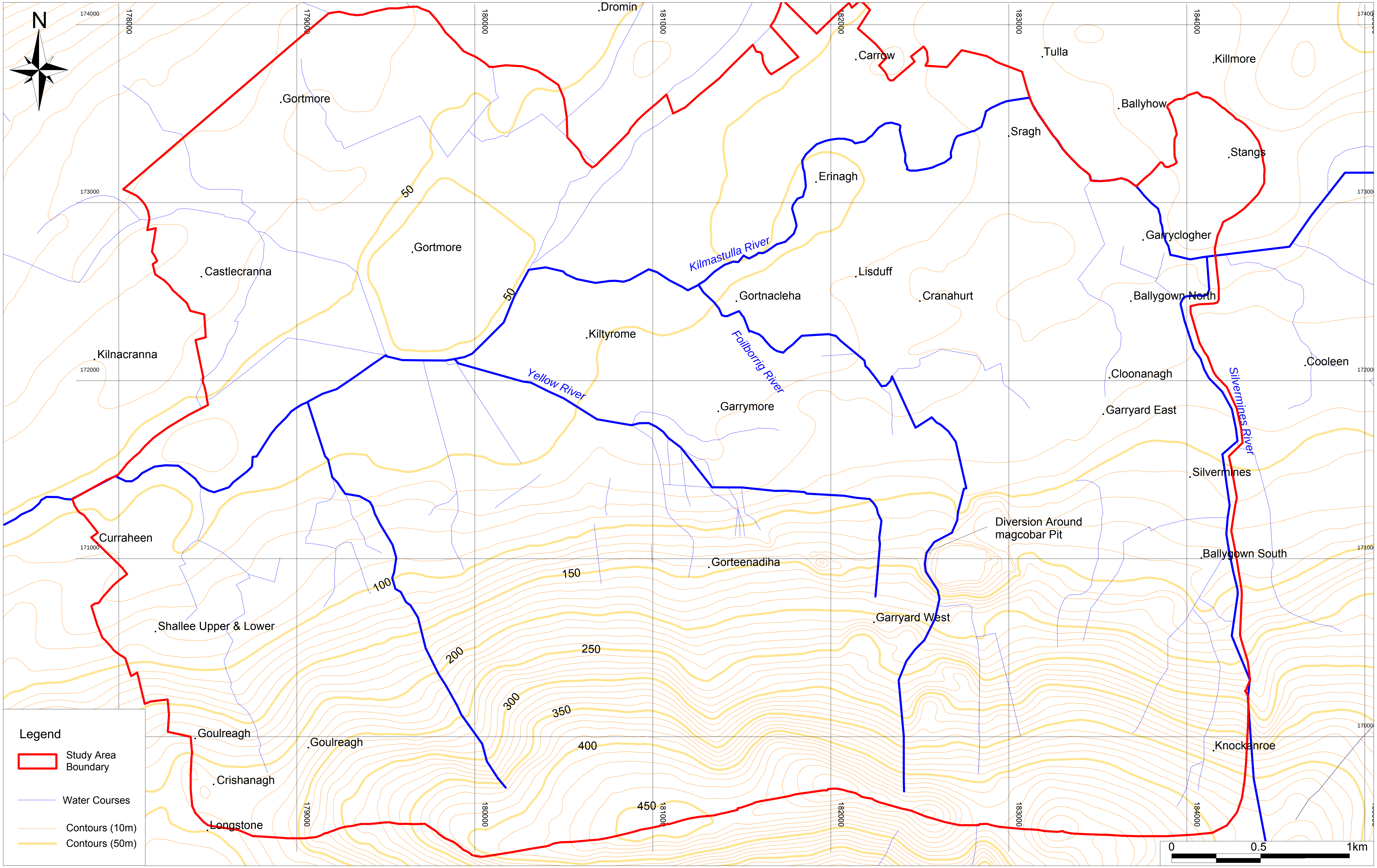
The Silvermines area is located on the northern slope of the Silvermines Mountains, which rise to approximately 490m AOD. To the north, the area is bounded by the Arra Mountains which rise to approximately 560m AOD. Combined, the two mountain ranges form the southern and northern limbs of the Kilmastulla syncline structure and govern the drainage pattern. The southern half of the study area extends from the crest of the Silvermines Mountain to the toe, with a ground slope of 1 in 3 at the crest to 1in 10 on the lower slopes. The northern section is flat and poorly-drained. The mines are on the lower slopes and toe of the Silvermines Mountain, except for the Garryard (Mogul) plant and part of the underground workings, which are on the adjacent flat land.

Figure 5.1 shows the topography and drainage of the study area. The main water course is the River Kilmastulla, with its source high in the Silvermines Mountains. On reaching the main valley floor, the river turns sharply to the west, eventually joining the Shannon River approximately 15km from the source. The river channel has been changed by mining activity. This has included deepening and straightening. Other changes have included river re-alignment to reduce peak flood levels and erosion, and culverting of tributary streams, such as at Magcobar.

In the western part of the catchment the river flows east through the Kilmastulla synclinal structure where the topography is slightly rolling. Further to the West, the river bisects the Devonian Formations and tends to follow the trend of the Silvermines Fault

The mining areas are drained by a number of streams feeding the Kilmastulla River:

- Ballygown is drained by the Silvermines River
- Two tributaries of the Foilborrig River pass through Magcobar, and have been diverted around the Magcobar pit.



(Source: Ordnance Survey of Ireland, 2001).

MARCH 2001	U1606	SILVERMINES	1:20,000
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- The Garryard settling pond and lagoon feed tributaries of the Yellow River, and one tributary from the west of Magcobar has been diverted along the main road to avoid the Garryard plant area.
- An unnamed stream and its tributaries flow through the Shallee South/East area.
- The Kilmastulla River itself has been diverted around the perimeter of the Gortmore TMF.

In addition to the natural and diverted streams, there is a network of drains in the flat northern part of the study area.

5.2 Land ownership and mineral title

This aspect will be investigated in detail by DMNR

5.2.1 Land ownership

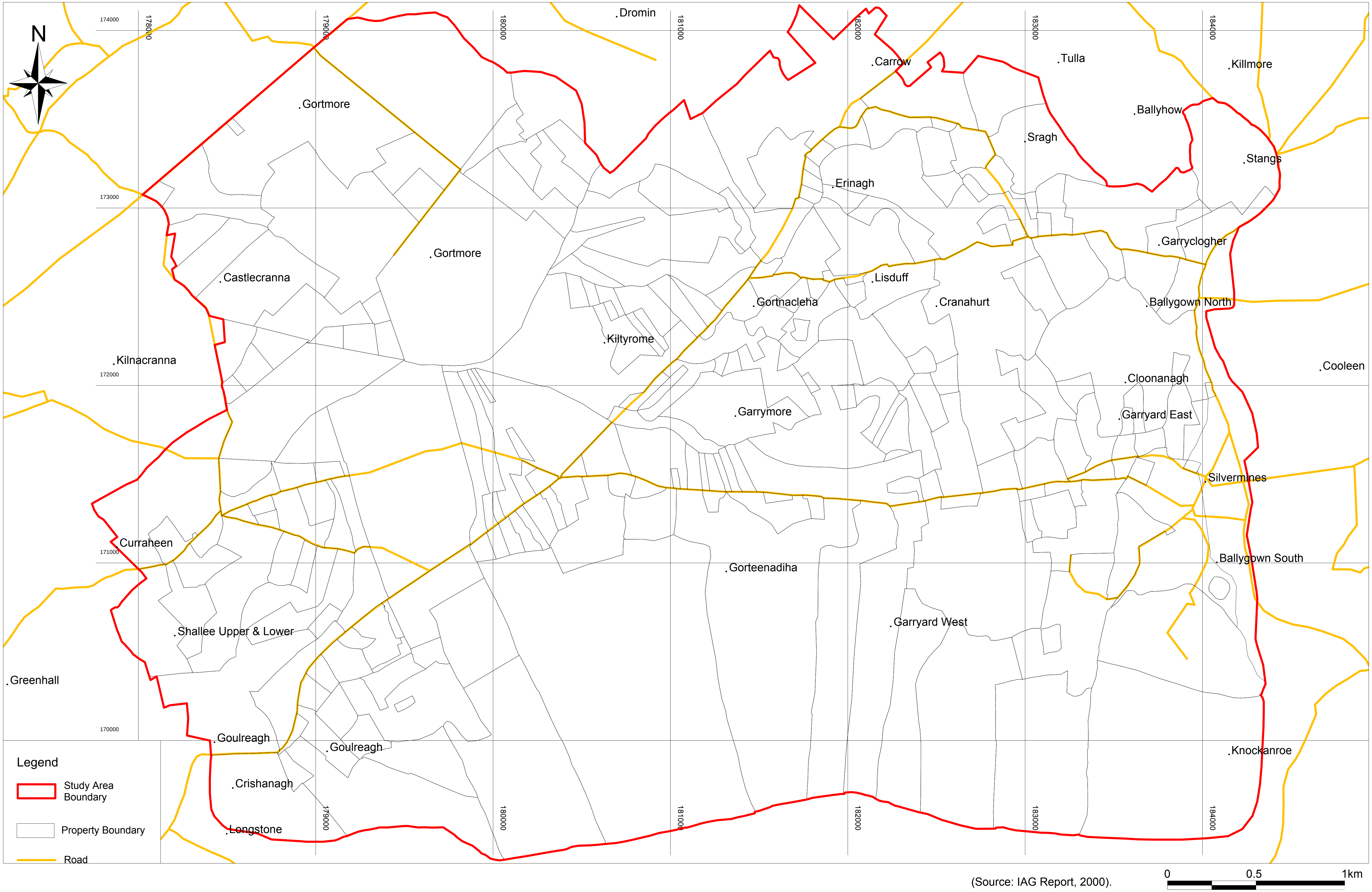
The study area includes approximately ninety farms, the mine properties and the associated surface works and dumps, and Silvermines village (Figure 5.2, information supplied by K.T. Cullen Consultants[107] from the IAG study[87]).

5.2.2 Mineral title

The following information on Mineral Title is taken from the IAG report[87].

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:



MARCH 2001	U1606	SILVERMINES	1:20,000
SRK Consulting Engineers and Scientists		PROPERTY BOUNDARIES	Fig 5.2

- 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 mineral title is shown on. Figure 5.3 [107].

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.

5.3 Climate

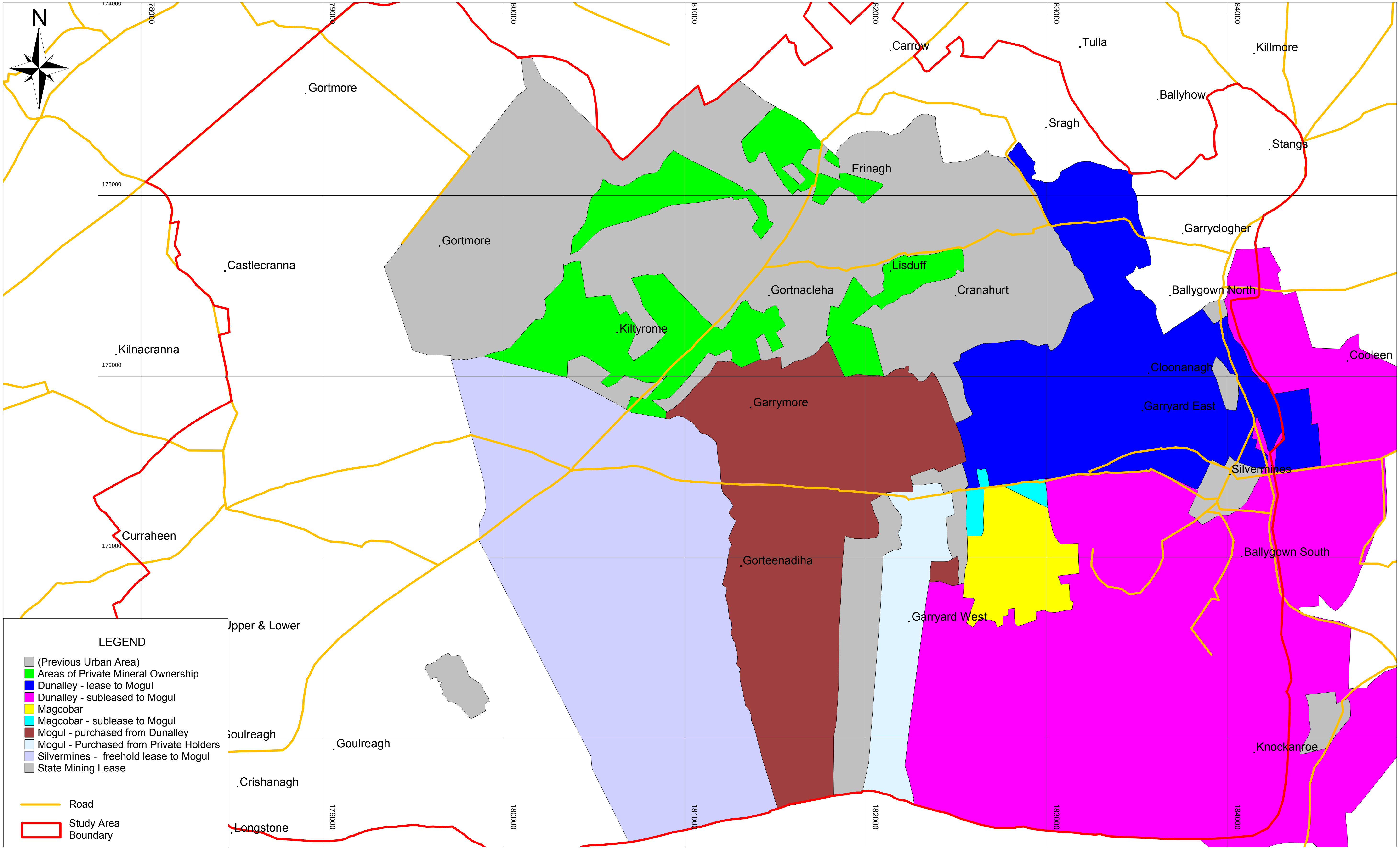
The following section is based on the assessment of Aslibekian[109], which was based on information from the meteorological stations at Nenagh, (50m AOD), Curreeny (312 mAOD), Birr and Kilkenny.

The elevated relief of the Silvermines and Arra Mountains strongly influence the local climate, particularly precipitation. For instance, long-term average rainfall in the lowlands is 848mm/yr while at the elevated Curreeny station it is 1633mm/yr. The EPA give a long term average for the Kilmastulla catchment at Cool Bridge (hydrometric station #2544, catchment area 98.9km^2) of 1157mm/yr and long term average actual evaporation as 455mm/yr.

Wind events have been a significant element of the historical problems, principally due to dispersion of mobile surface deposits from the GTMF. Gauging of the aerial deposition and dust chemistry has been undertaken and is described in section 5.10.3.

5.4 Geology and soils

The earliest geological description was by the Geological Survey of Ireland, with publication of the first series of maps and memoirs (Wynne and Kane, 1861[7]). More recent workers have focused on description of the orebodies (Griffith, 1952[9]; Rhoden, 1957[10]; Taylor and Andrew, 1978[36]; Boyce *et al.*, 1983[46]; Samson and Russell, 1987[55]; Andrew, 1986[53], 1991[59], 1995[64]) and genesis (Andrew, 1986; Samson and Russell, 1987[55]).



(Source: IAG Report, 2000).

0 0.5 1km

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SRK Consulting Engineers and Scientists		MAP OF MINERAL OWNERSHIP	Fig 5.3

5.4.1 Regional geology

The geology of the area and its surroundings is well documented. This section is taken from the description of Andrew (1986[53]).

The Silvermines area lies on a fault-bounded southern limb of the asymmetric Kilmastulla Syncline that trends and gently plunges ENE. Dips are generally 10^o on the northern limb and 15^o on the southern increasing to 60^o in the drag attenuation zone of the Silvermines Fault. The syncline is thought to represent the southernmost extremity of the Central Midlands syncline which runs SW from Navan via Tullamore to Nenagh. To the north-east of the area, the Lower Carboniferous succession gradually thickens and the Courceyan carbonates become superseded by Chadian to Holkerian shelf limestones.

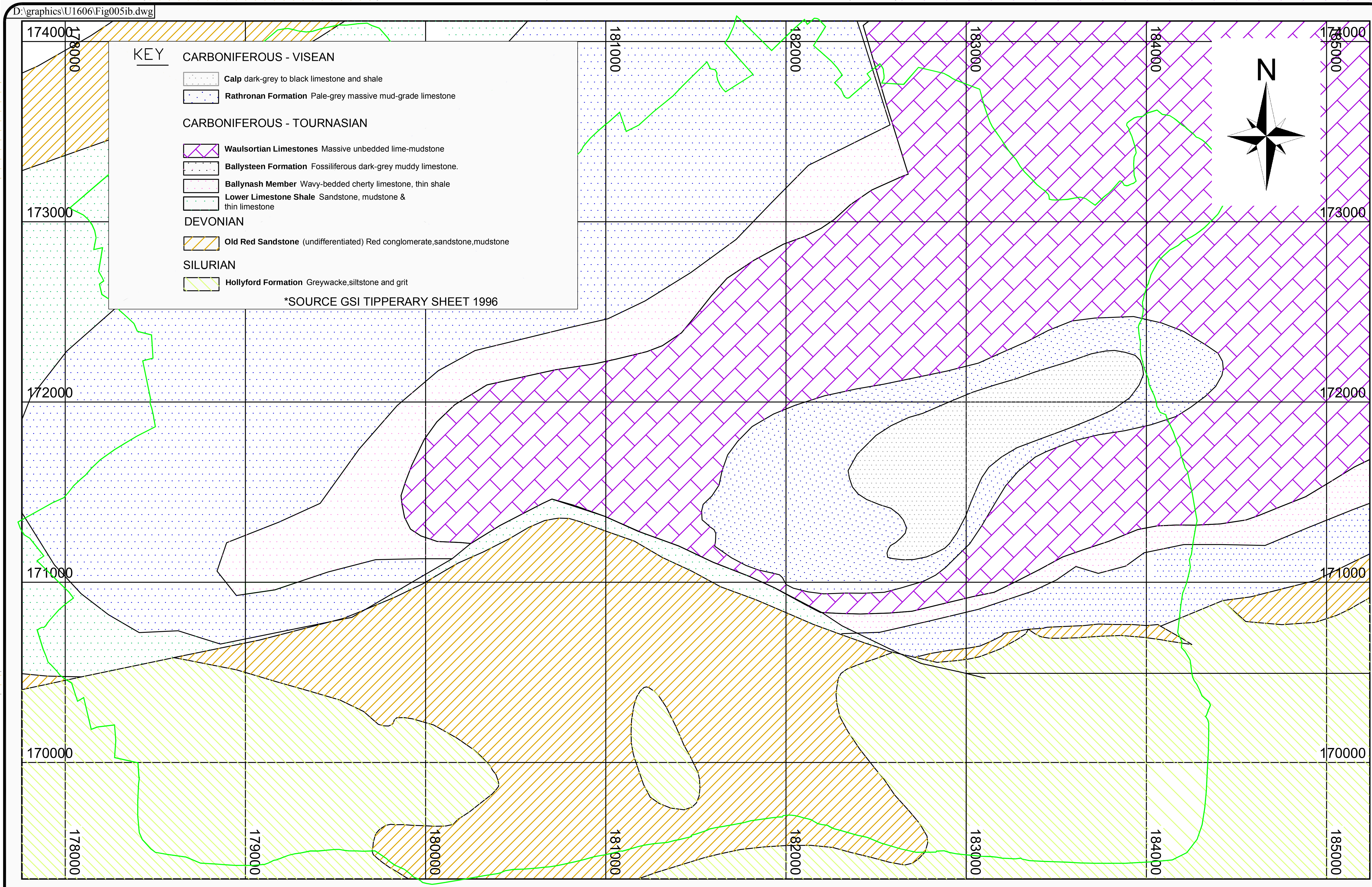
To the north-west of Silvermines are the Arra Mountains which comprise upper Llandovery greywackes and shelly faunas. These Lower Palaeozoic inliers form part of the larger Slieve Phelim-Slieve Aughty massif, which was an active palaeohigh during the early Carboniferous, defining an area of attenuated sedimentation from the Courceyan to Brigantian stages.

5.4.2 Geology of the study area

The geology of the study area (Figure 5.4a) has been taken from the 1/100,000 geological map (Geological Survey of Ireland, 1996). More detailed information is available for the mining area at Silvermines, and this is shown separately on Figure 5.4b (Mogul of Ireland and Golder Associates).

In the Silvermines area, base metal-barite mineralisation occurs within the basal Carboniferous (Courceyan, c.355 Ma) transgressive siliclastics and in overlying carbonate rocks (Figure 5.4b). Regionally the deposits lie on the northern flank of the Slieve Phelim-Slieve Aughty massif that forms the SW limit of the Central Midlands Basin (Andrew, 1992).

The detailed stratigraphy and petrography of rock types in the Silvermines area has been described in detail elsewhere (Taylor and Andrew, 1978[36]; Andrew, 1986[53]). The ore-forming sediments at Silvermines pass up from alluvial plain and marine clastics through transgressive muddy lagoonal and estuarine carbonates to shallow water bioclastic limestones. The ore-hosting breccias that formed are thus sandwiched between Footwall pale reef (massive) Limestone and the Upper reef Limestone (both Waulsortian). Figure 5.5 shows a summary stratigraphic column.



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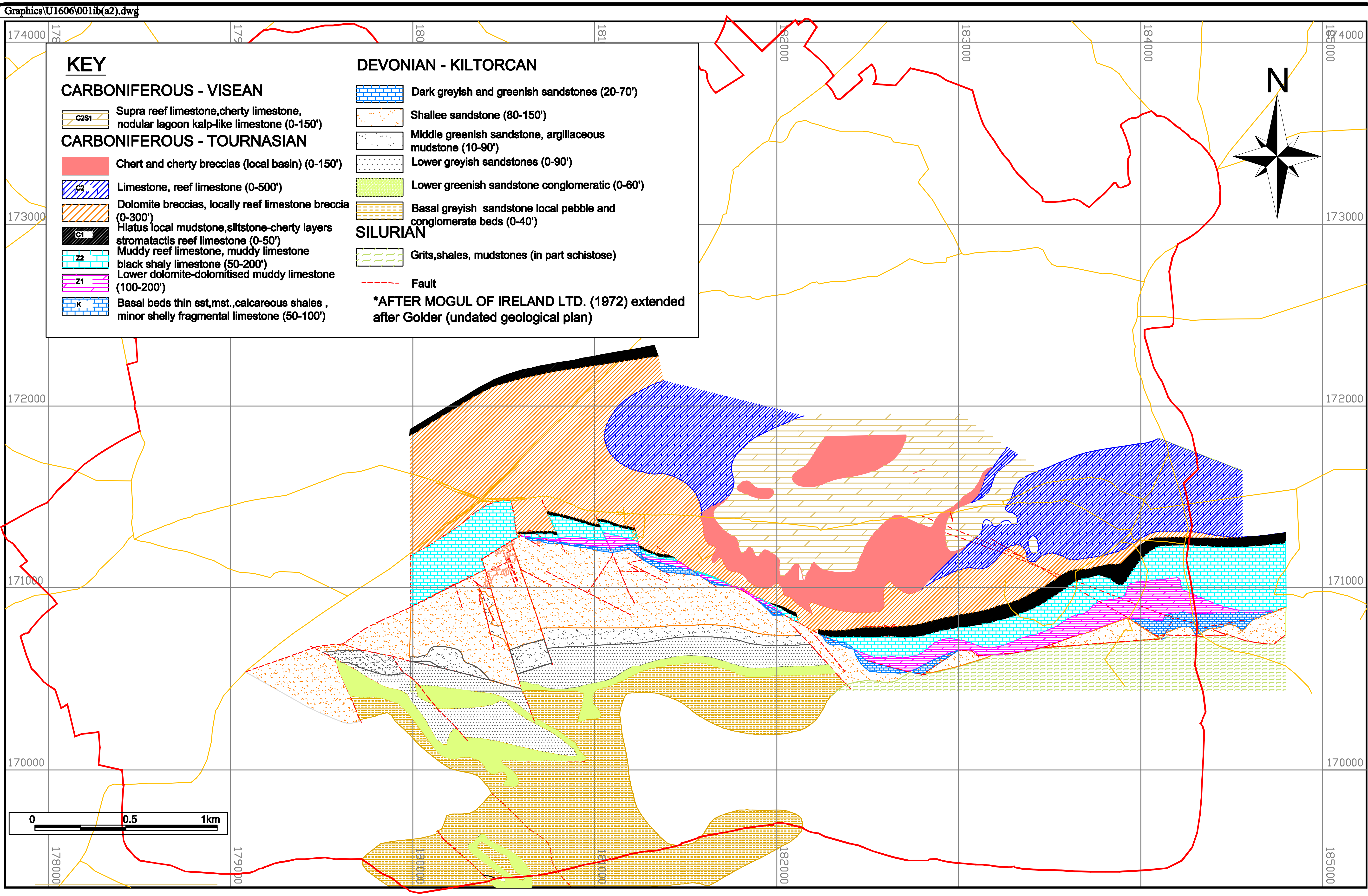
GEOLOGICAL PLAN OF STUDY AREA

(see Fig 5.4(b)for detailed geology of mining area)

Fig 5.4(a)



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SRK Consulting Engineers and Scientists		DETAILED GEOLOGICAL PLAN OF MINING AREA (see fig 5.4(a) for general geology of entire study area)	Fig 5.4(b)

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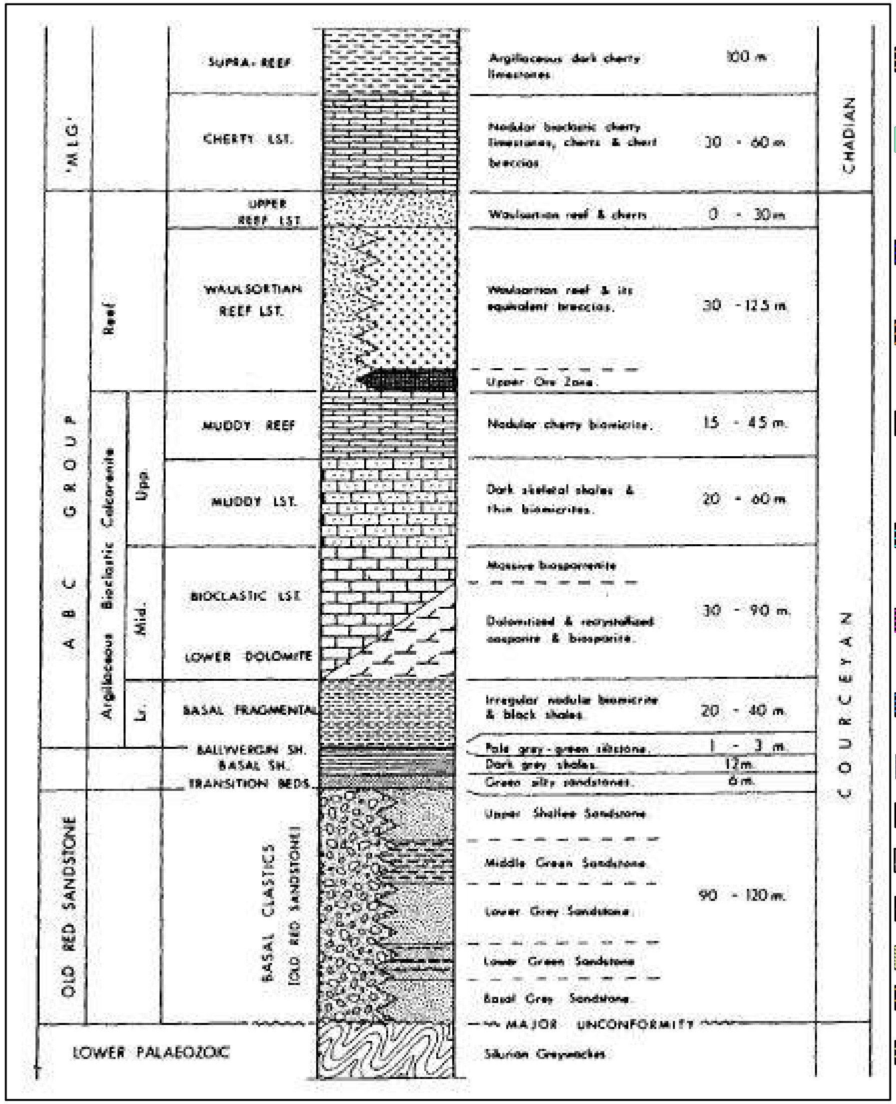


FROM ANDREW (1986)

EQUIVALENT STRATIGRAPHIC UNITS AS MAPPED BY MOGUL OF IRELAND(SEE FIG 5.4)

- C2S1 — Supra reef limestone,cherty limestone,nodular lagoon kalp-like limestone (0-150')
- Chert and cherty breccias (local basin) (0-150')
- Limestone, reef limestone (0-500')
- Dolomite breccias, locally reef limestone breccia (0-300')
- C1 — Hiatus local mudstone,siltstone-cherty layers stromatactis reef limestone (0-50')
- Z2 — Muddy reef limestone, muddy limestone black shaly limestone (50-200')
- Z1 — Lower dolomite-dolomitised muddy limestone (100-200')
- K — Basal beds thin sst,mst.,calcareous shales, minor shelly fragmental limestone (50-100')
- Dark greyish and greenish sandstones (20-70')
- Shallee sandstone (80-150')
- Middle greenish sandstone, argillaceous mudstone (10-90')
- Lower greyish sandstones (0-90')
- Lower greenish sandstone conglomeratic (0-60')
- Basal greyish sandstone local pebble and conglomerate beds (0-40')
- Grits,shales, mudstones (in part schistose)

April 2001	PROJ. No: U1606	SILVERMINES	N.T.S.
SRK Consulting Engineers and Scientists		Summary Stratigraphic Column for the Silvermines area	Fig 5.5

Mineralisation in the area comprises of marcasite, base metal, siderite and barite facies in all levels of the Waulsortian Equivalent succession and in numerous tectonic and geological settings. These can be summarised as four groups:

- Tabular parallel bedded zones at the base of the succession. Typically these contain debris-flows of mineralised clasts in the hanging walls e.g. Upper, G & B and Magcobar zones
- Cavity and fracture-fill zones in the Lower Dolomite as in the Lower G, K and P zones of Mogul mines
- Complex breccia zones within dilational settings in the Basal Clastics such as at Gorteenadiha, Shallee and Knockanroe.
- Simple and layered vein deposits in joints and fractures such as the numerous small developments throughout the Silvermines Mountains as well as Shallee west.

5.4.3 Environmental Geology

Sulphide mineralisation of the type observed in the Silvermines area has the potential to impact the environment through:

- Metal and salt release related to oxidation of sulphides and dissolution of secondary metal precipitates;
- Acid Generation, and;
- Increasing Total dissolved Solids (TDS).

The infill and breccia styles of mineralisation, particularly in the vicinity of Mogul mine show a high marcasite and pyrite content and as such have a high potential for acid generation. The mineralised zones in these areas also have the highest potential for metal release due to:

- Fine grained nature of the mineralisation;
- Massive nature of sulphide zones, and;
- Presence of base metal sulphides as well as high trace elements in rare sulphides such as tetrahedrite, cobaltite, pyrrhotite, arsenopyrite and rare Cu-Zn-Ag-Cd-Ge-As-Sb-Pb sulfosalts.

Vein style mineralisation is unlikely to impact as much as the above types of mineralisation because:

- There is a lower portion of total sulphides especially acid generating Fe sulphides;
- Coarser grained sulphides;
- Sulphides are isolated in insulating gangue phases, and;
- Higher carbonate content in mineralised lodes.

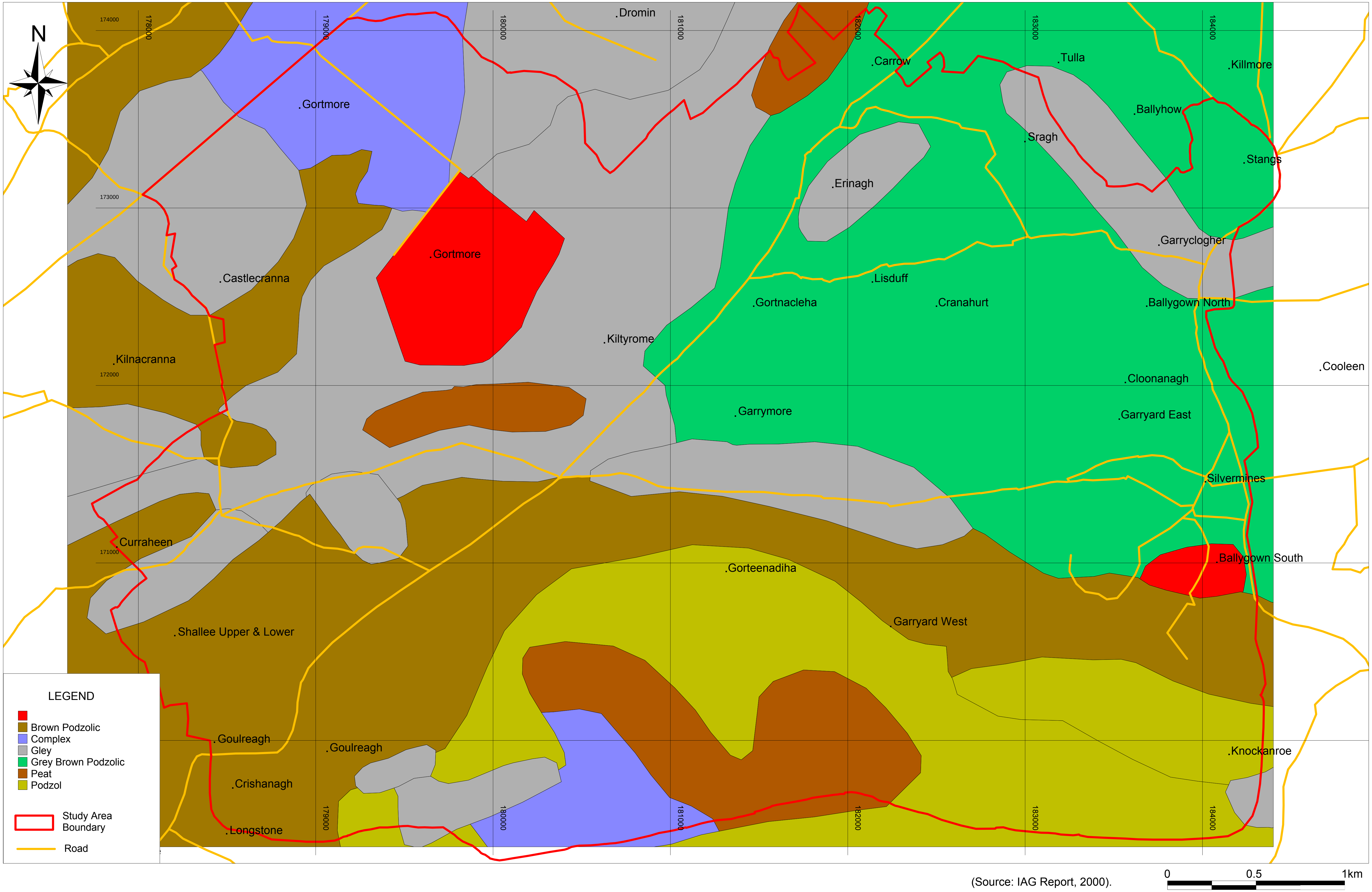
The host rock is predominantly carbonates which generally have a high potential for acid buffering and thus metal precipitation occurs as carbonate, hydroxide or oxide minerals.

5.4.4 Soils

According to the classification of Finch and Gardiner in their soil Survey of Tipperary North Riding, three soil series (Borrisoleigh, Borrisoleigh-Ballinalackan and Elton) comprise much of the area (Figure 5.6)[107]. The soils are in general productive, but include areas where agricultural use is severely restricted. Background soil metal concentrations for Ireland were established by McGrath and McCormack (1999). They indicated that most soils in Ireland contain ~25mg/kg Pb, slightly less Cu and As and slightly more Zn. Cadmium is typically <1mg/kg. In the Silvermines area, where the geological formations contain large quantities of metals, it can be expected that the background soil metal concentrations will be significantly higher than those for Ireland as a whole.

One of the earliest chemical soil analysis in the Silvermines area was undertaken by Mogul in 1963 as part of mineral exploration work. The survey included an analytical technique referred to as the 'Bloom Cold Extract Method' which is aimed at measuring freely available Pb. Elevated levels (>5000 mg/kg) were found in and around Silvermines village, along the foot of the north side of the Silvermines mountain, around Shallee and Gortmore and in the north around Ernagh. The data indicates that elevated soil Pb concentrations existed in the vicinity of the GTMF, prior to construction. Soil data also exists from 1976, 1978 and 1981.

There is herbage data from 1967, 1968, 1975 (water weeds from the Kilmastulla River and field vegetation from the area around the Garryard Plant and the Gortmore TMF). Again, these surveys were undertaken for Mogul. Sampling localities are known and the data provides an indication of metal (Cu, Pb, Zn) concentrations within the area at these times. Units of measurement are not available, and it has been assumed the data reported is mg/kg. Soil samples were also collected from different depths, some of which are not known. Therefore, temporal and spatial interpretation is lacking.



MARCH 2001	U1606	SILVERMINES	1:20,000
SRK Consulting Engineers and Scientists		SOIL MAP	Fig 5.6

In summary, the data indicates that a number of highly elevated metals contents existed at these times. For instance, in 1978 one soil sample contained 13600 mg/kg Pb, another contained 4600 mg/kg Zn and another 505 mg/kg Cu. In 1968 and 1981, such elevated levels were not found, with Pb not exceeding 4000 mg/kg and Cu 500 mg/kg. The exception is Zn, which in 1968 had values up to 8000 mg/kg but in1981 levels never exceeded 2000 mg/kg. Overall, for all three sampling periods, Cu rarely exceeded 50 mg/kg, Pb 1000 mg/kg and Zn 500 mg/kg. These levels are elevated however.

Following dust blows in early 1985, 86 soil samples and 50 herbage / fodder sample were taken from farms adjacent to the GTMF during five sampling events by Teagasc personnel. The survey indicated that soil Pb concentrations for the area were generally low and decreased with depth which was concluded to be indicative of dust deposition. In a later survey (November 1985), soil Pb values ranged from <100 mg/kg to almost 20000 mg/kg in other farms in the Silvermines area.

The most recent soil investigation was conducted as part of the IAG[87] study. This comprised a phased approach with an initial exploratory investigation aimed at developing site specific techniques for sampling and analysis. This survey covered the Gortmore TMF and the surrounding area. The second phase of investigation was conducted in the Autumn of 1999 and comprised the collection of soils (to a depth of 10cm) and herbage (cut to within 50mm of the soil surface) over an area which extended 3km north and 2km south of an east-west line from Silvermines village to Kilnacranna. Samples of silage, hay and animal drinking water were also collected from farms in the area. Soil samples were analysed for As, Pb, Zn, Cu, Cd, pH and loss on ignition (organic matter content). The results from this analysis (apart from organic matter content) are summarised as contoured plots in Figures 5.7-5.12 of the IAG report and Appendix 4 of the report.

The results from the initial survey indicated that some agricultural soils in the area had elevated Pb, Zn and Cd that allowed for the possibility of impact on crops and animals. As expected, the samples from the GTMF had significantly higher heavy metals contents. The follow-on survey indicated that agricultural soils contained very high metals concentrations. Of the 213 soils sampled, ~20% had Pb values >1000 mg/kg and these were also found to be enriched in Zn. Soil Cd concentrations were >1mg/kg over a large part of the area. Soil heavy metal accumulation (Pb, Zn, Cu, As and Cd) was generally associated with either the GTMF, the Shallee area, the Kilmastulla River and its tributary the Silvermines River.

The only exception was the area south of Shallee, where Zn and Cd were depleted. This was considered to be due to soil acidification promoting leaching of the metals.

Outside the GTMF, Cu and As concentrations are not notably elevated above background levels.

Elevated acidity and low phosphorous were pronounced in the area. In addition to affecting the growth of grass this could potentially affect the bio-availability of Pb. Phosphate can assist in the formation of more inactive forms of Pb in soil. If action were taken to improve soil fertility through Ca and phosphate addition, the increased Ca and phosphate concentrations could reduce the bioavailability of Pb. An assessment of the leachability of Pb, Zn and Cd from soil in the Kilmastulla flood plain indicated levels were high (Aslibekian[109]).

As part of the IAG study, 31 soil samples (0-10 cm depth) were taken on a 18×20m grid within the school play area and analysed for Pb, Zn, Cd and Cu. The sampling confirmed that soil metals content was elevated (Pb ranging from 2000 – 37000 mg/kg). The spatial distribution of the other metals generally followed that of Pb.

The school playing field has now been covered by a gravel drainage layer (capillary break) and one metre of imported fill.

Additional sampling of soils may be required, and this will be determined during Phase II.

5.5 Surface water

5.5.1 The natural surface water regime

The Silvermines area is within the catchment of the Kilmastulla River, bounded to the south by the Silvermines Mountains and to the north-west by the Arra Mountains. The river flows to the west where it discharges to the River Shannon ~13km downstream. The only gauging station on the Kilmastulla river is near the Cool bridge (NG_R710 694) about 2km east of the confluence with the Shannon River. The catchment area of the Kilmastulla River is 98.9sq km at the Cool bridge.

Due to seasonal variations in rainfall, there is significant variation in river discharge which can vary between less than $0.2m^3/s$ to $15m^3/s$ (Aslibekian[109], 2000). Between 1975 and 1993 average flow was approximately $2.13m^3/s$ with the 95 percentile flow being $0.26m^3/s$ (Magcobar report[109]).

A series of springs and streams drain from the hillside and some of the local farmers pipe spring water from above the mine workings. These small streams drain into the

Silvermines River at the east end of the area and the Yellow River and Foilborrig River draining from the Garryard to Shallee areas

All of the drainage from the mine sites enters the Kilmastulla River above or at the GTMF. This river has been diverted around the GTMF.

There is no flow information on any of the tributary rivers. Some estimates of flows were taken on some streams during the site visits. Estimates of flow ranges from various sub-catchments will be made in Phase II based on extrapolation from the Kilmastulla River flow record. More detailed flow monitoring from any sub-catchment will be recommended in the final report, if it is considered necessary for water management and remediation purposes.

5.5.2 The influence of mining on the surface water regime

Mining has impacted on surface water in a number of ways:

- Interception of surface flow and interflow from the hillside by drainage cut-offs, the open pit works and the collapsed underground workings;
- Increased runoff in areas of bare soil or rock;
- Increased suspended solids and dissolved solids;
- Artificial diversions around mine infrastructure.

The intercepted flow may have the benefit of providing retention storage to limit the potential effects of flooding but this will be balanced by the increased runoff from bare areas and the potential for contamination in the mine workings.

This is illustrated by the Mogul shaft and the drainage adit from Calamine, which appear to continuously discharge water but respond with much higher flows about 24 hours after rainfall events.

Extensive surface drainage cut-offs have been constructed above the various rock dumps and the pit at Magcobar. The streams flow under the haul road rock dumps and into a concrete channel which diverts the water around the open pit and into the stream below the plant site. At Shallee there are also surface cut-offs collecting seepage water from above the open workings and diverting it to the east of the mine area. There are waste dumps immediately adjacent to the natural stream on the north side of the Shallee east site that enable contaminated run-off and erosion products to enter the stream directly. A similar situation exists at Calamine where the waste material has been tipped on the banks of the Silvermines River.

5.5.3 Surface water quality

Surface water quality has been monitored for biological and chemical quality over a period of some 30 years. Due to an increase in the detection limit of many metals during this time, the most useful information comes from the more recent studies, particularly post 1990.

The focus of the investigations to date has been on the toxic metals content and lead in particular. However, mine drainage will also result in elevated salt levels which may have some environmental considerations and will be addressed in Phase II.

Biological Quality

Biological monitoring of the Kilmastulla commenced in 1971. More recently, the IAG study[87] included monitoring the Kilmastulla and Yellow Rivers. This latter survey included monitoring of biological and chemical parameters.

The main conclusion from the biological surveys conducted since 1971 is that biological water quality on the Kilmastulla upstream of the Silvermines village is rated as fair and unpolluted. Downstream of the confluence with the Yellow River, the quality is reduced and characterised as moderate. This was considered to be due to pollution at Cranna bridge due to siltation and organics from farm slurry. No toxic effects on invertebrates were noted in the Kilmastulla in the 1999 survey although in 1993 and 1996 toxic effects were noted.

Since 1971 all monitoring stations on the Yellow River have indicated a toxic effect on the basis of heavy metals such as Pb, Cd and Zn impacting the invertebrates. The stream draining the Garryard mine complex had the poorest water quality although there is a significant dilution effect in the Kilmastulla river.

Chemical monitoring

During the period 1992-1998 elevated levels of Pb, Cd and Zn in the Kilmastulla and Yellow River were found. The highest recorded Pb concentration (0.735mg/l) was found upstream of the confluence between the Yellow River and the stream draining the Garryard mine complex. Elevated concentrations of Pb, Cd and Zn were also found in the stream draining the Garryard mine complex. Downstream of the confluence and the Garryard mine complex concentrations of Pb, Cd and Zn remain elevated.

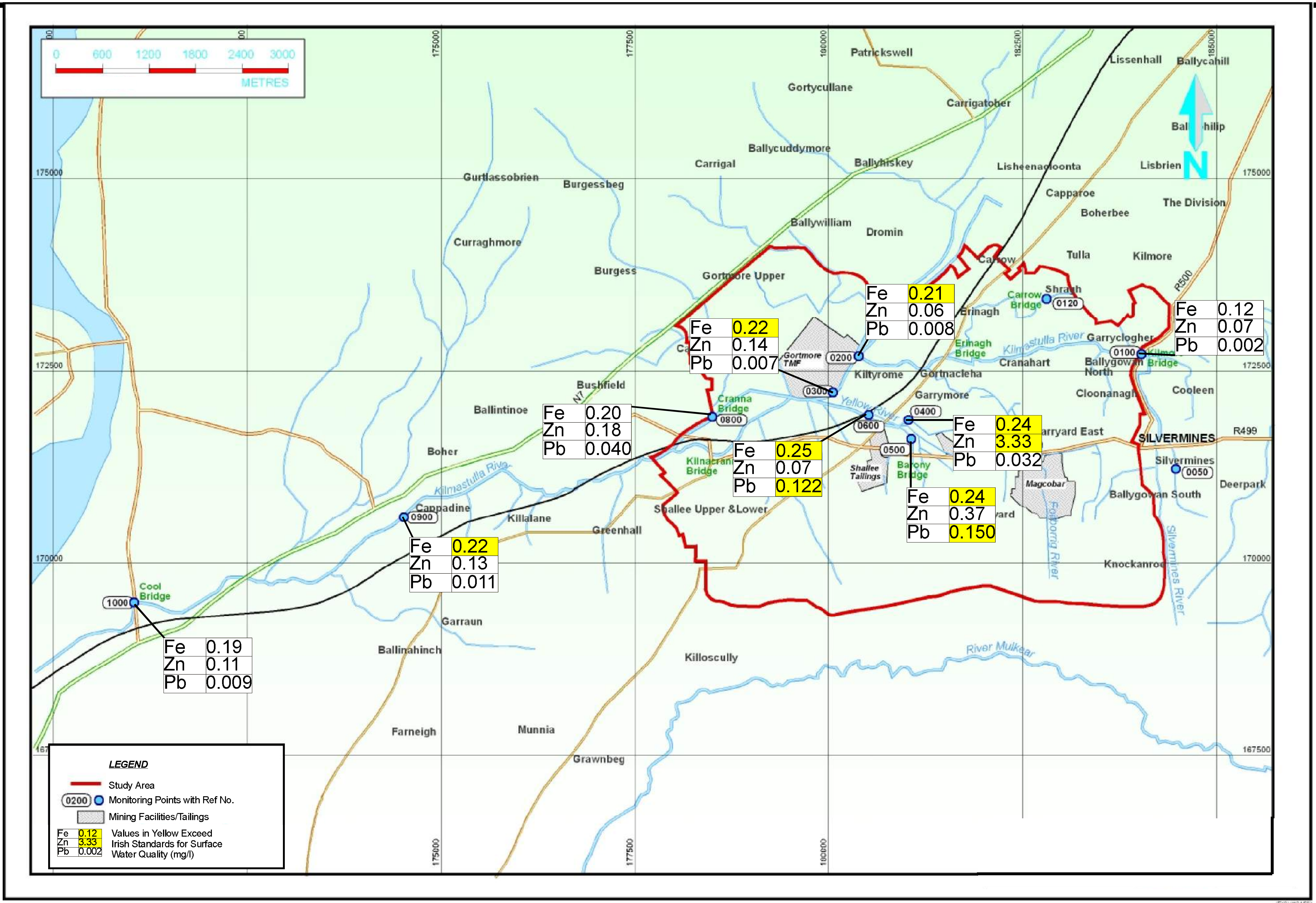
In 1999, 19 additional surface water locations were sampled. Some of these coincided with the earlier monitoring sites although streams to the north and more detailed sampling of the mined areas, particularly the Garryard complex were included. This data is reported in Appendix 3 of the IAG report. Essentially, the monitoring data corroborated the earlier routine monitoring. However, some significant parameters are not reported in the IAG report – these include alkalinity and dissolved oxygen. It is to be confirmed in Phase II whether or not these measurements were made. The study of Aslibekian (2000)[109] included an assessment of alkalinity values within the Kilmastulla catchment. It was concluded that most waters within the area had good acid buffering potential as alkalinity varies between 114 and 287 mg/l (units of alkalinity not reported). The higher values tended to be in the east due to the underlying limestones.

The samples taken from the tailings lagoon and settlement pond at the Garryard complex had some of the highest metal contents reported (3.4mg/l Fe, 0.3mg/l Pb, 0.01mg/l Cd, 0.08mg/l Al and 0.19mg/l Mn). Streams sampled immediately downstream of the GTMF and the Shallee tailings also had elevated levels of Pb. Interestingly, the streams sampled east, upstream of the GTMF contained up to 0.6mg/l Fe and 0.045mg/l Pb and 0.1mg/l Zn.

SRK understands the routine monitoring of surface water by the EPA is on going. SRK were supplied with such information for the period January 1999 – October 2000. More recent information is available and will be made available to SRK. As shown by previous monitoring, this data indicates that elevated levels of metals (Fe, Zn and Pb) tend to occur downstream of the Garryard mining complex, the Shallee tailings and the workings between Magcobar pit and the Shallee tailings. On average for the period however, Fe concentrations never exceed 0.25mg/l and Pb concentrations 0.05mg/l. Downstream of the Garryard complex, average Zn was 3.3mg/l. Further downstream at Cappadine, metals concentrations were significantly lower, presumably due to dilution. The spatial distribution of this information for a number of metals is illustrated on Figure 5.7.

Prior to open-pit mining at Magcobar, surface drainage in the area was dominated by two small streams, one of which is referred to as the Foilborrig River. To facilitate mining, these were culverted and directed via a concrete channel to the west to rejoin the streams to the north of the pit. During high rainfall periods, the easternmost stream has been noted discharging to the pit.

During the EIS[3] undertaken to assess the open pit as a landfill site, surface water quality was assessed in the area. Ten water samples were collected in August 1998 from locations summarised in Table 5.1.



(Source: IAG Report, 2000).

APRIL 2001	U1606	SILVERMINES	
SRK Consulting Engineers and Scientists		**AVERAGE SURFACE WATER QUALITY RELATIVE TO IRISH STANDARDS FOR THE PERIOD 01/1999 - 10/2000**	Fig 5.7

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Table 5.1 Surface water sites sampled around Magcobar as part of EIS

SAMPLE NO.	LOCATION
SW 1	Upstream from open pit
SW 2	Culvert to south of pit
SW 3	Ford Foilborrig stream, south of pit by roadside.
SW 4	Tributary to the Foilborrig 1km South of the pit
SW 5	Ford Foilborrig stream, just upstream of confluence with Shanacool River
SW 6	Shanacool river, just upstream of Foilborrig.
SW 7	Spring
SW 8	Gowlaun Glen stream, by roadside
SW 9	Kilmastulla river, north of Aughboy
SW 10	Kilmastulla River. By Cranna Bridge

The detailed results from this sampling are given in the EIS report. All waters were circumneutral to alkali with a pH between 7.3 and 8.2 and alkalinity between 30 and 326mg/l $CaCO_3$. Most waters were moderately mineralised with EC values up to 600µS/cm, although an EC value of 5920µS/cm was reported at SW10. This value is not consistent with the chemistry and should be considered spurious. In terms of trace metals, all waters apart from SW1 and SW9 contained detectable levels of at least one of the following metals – Zn, Pb, Cu, Ni, Fe, Al and Mn. Of these Zn was the most widespread. The highest levels of Fe, Cu and Pb were found at the spring at SW7 (18, 0.05 and 0.166 mg/l respectively). Some of the values recorded exceed the Maximum allowable Concentration (MAC) for surface water abstraction.

In April 1998, the EPA undertook monitoring around the Magcobar area. This information was supplied to SRK as a fax on April 5th 2001, accompanied by a sketch of the location of the sample points. This sampling indicated that the drainage in the concrete channel was of a fairly good quality with pH 8 and low metals content (0.1mg/l Fe, <0.003 mg/l Pb and 0.3mg/l Zn). Alkalinity was however low at 54mg/l $CaCO_3$. This could be due to the geology of the drainage area which comprises Devonian and Silurian sandstones and shales.

5.5.4 Magcobar Pit Lake Water Quality

Since the cessation of mining in 1993 the Magcobar excavation has largely filled with water forming a pit lake. The lake is considered to contain a component of surface water and groundwater although the proportion of each, which will effect pit lake chemistry, is unknown. It is also unknown whether the lake is a sump or groundwater passes through it. This will be investigated further in Phase II.

Mining records suggest that groundwater inflow to the pit and to the underground works was limited. It can be assumed that recovery of the water level was largely due to surface water inflow, especially now that the water level appears to have stabilised. The position of the natural groundwater level compared to the pit water level is unknown although there are some test boreholes drilled by Dunnes for the waste disposal project. These will be investigated in Phase II.

Aslibekian (pers. comm.) considers that the pit lake has recovered in a low permeability rock mass but the water level has reached the zone of greater weathering and higher permeability and is now discharging in to the ground. This discharge may be slightly above the natural groundwater level. During the field visit a 'tidemark' of orange staining was observed suggesting that there is fluctuation of the present level depending on rainfall but that it is essentially stable at the present level. Groundwater levels in the Mogul workings are about 20 to 30m below ground surface in the collapse areas, but this requires confirmation in Phase II.

Up until 2000, only two known water samples for analysis have been collected from the surface of the pit lake. The first sample was collected by the EPA in April 1998. At this time, the lake had a pH of 7, alkalinity of just 20mg/l $CaCO_3$ and an EC of 10745µS/cm. Zinc was the dominant metal detected (5.8mg/l) with 0.28mg/l Fe and 0.007mg/l Pb. Cadmium was elevated, with 0.015mg/l detected. Calcium, Mg and SO_4 were not reported.

The second sample was collected as part of an EIS[3] (Environmental Impact Statement) for the proposed land fill site at Magcobar open pit on August 18th 1998 (B.J.Murphy & Associates). The position of sampling is unknown and the results are given in the EIS report. The chemistry reported does not appear internally consistent as the water was reported to have a pH of 7, <25mg/l $CaCO_3$ and a total carbonate hardness of 625mg/l $CaCO_3$, although it is similar to the sample collected in April. The data indicated elevated levels of SO_4 (563 mg/l), Fe (5.1 mg/l), Sr (1.4mg/l), Zn (6.3mg/l), Pb (0.032mg/l), Ni (0.076mg/l), Mn (0.73mg/l), Al (0.6mg/l) and Cd (0.019mg/l). Some of these values exceed the MAC value for surface water abstraction.

The sampling of Aslibekian (2000)[109] has enabled the chemistry of the pit lake to be better understood as samples from different depths have been collected. This data is presented in Appendix 6 of the thesis and is not reproduced here. The data indicated that the water is more acidic and contained higher metals concentration at depth. This included Fe, Mn, Zn and SO_4. These vertical chemical variations reported may indicate that seasonal or permanent stratification has occurred in the lake, but this will be evaluated further in Phase II.

5.6 Stream Sediment Geochemistry

Stream sediment geochemistry near mining areas can be a function of erosion from contaminated sediments as well as precipitation from water draining from those areas. Surface water quality also influences the chemistry of the underlying stream sediment because metal and salt precipitation is promoted by the buffering potential offered by the surface water. Consequently, stream sediment metals concentrations are commonly elevated in close proximity to the mining complexes.

Mogul collected and tested stream sediments in 1971 and 1975. In conjunction with the sampling of surface water in 1999 by the EPA, sediments were collected from 19 sites within the Kilmastulla catchment. These were analysed for heavy metal contents which are reported in Appendix 3 of the IAG report[87]. Site identification was not coincident with the numbering system used for the surface water sites. The following discussion refers to sample sites indicated in diagrams in the IAG report and they are not repeated here. Further details will be presented in Phase II.

Subsequent stream sediment monitoring by the EPA was undertaken in August 2000[106]. Nine sites were sampled which were not the same as those in 1999, although the naming convention adopted was similar to that adopted in 1999.

In 1999[87], sediments with elevated metals concentrations were found throughout the area. This was particularly pronounced in a small stream draining the settlement pond located north of the railway line in the Garryard mine complex. The sediment (SS1) contained very high values for Fe (164258 mg/kg), Mn (14994 mg/kg), Ni (566 mg/kg), Co (147 mg/kg), Cu (642 mg/kg), Zn (208233 mg/kg), As (468 mg/kg), Se (7.2 mg/kg), Mo (3.1mg/kg), Cd (195.8 mg/kg), Sb (37.2 mg/kg), Tl (22.8 mg/kg), Pb (12332 mg/kg), Ag (11 mg/kg) and U (19.5 mg/kg).

A similarly high lead value was identified in the stream adjacent to the Shallee north tailings (sample SS15).

Upstream of the Yellow bridge, metals levels were elevated with the highest Tl noted (2.8mg/kg) and Pb 9454 mg/kg (SS14). Elevated levels were broadly sustained downstream, and west of the railway line but upstream of the Gortmore TMF, Pb was 9184 mg/kg, As 204 mg/kg and Zn 3570 mg/kg (SS16).

Sediment samples taken within close proximity to each other, downstream of the Magcobar mining area and the GTMF contained variable metals contents with generally lower values downstream of the GTMF. Both sites contained generally lower metal levels than the Garryard and Shallee samples. Similar spatial variations were seen around Silvermines village, Sragh, Gortnacleha and Ballygown North.

The occurrence of the high values to the north away from the mine areas is presumably related to accumulation of metals in the sediments of the main rivers (Kilmastulla, Silvermines and Yellow Rivers) draining from the key metal source areas. The apparent hot spots for metals shown by the stream sediment sampling (map 7) is a function of the distribution of sample points. The lead distribution in soil shown by map 1 is more general along the rivers probably due to stream sediment excavation.

The data collected in 2000[106] is anomalous, as a number of the detection limits quoted were not consistent between samples. For instance, at SS8 and SS9, the detection limits for Sn were <836 and <314 mg/kg respectively, while all other samples had detectable quantities of between 27 and 48 mg/kg. The following interpretation should therefore be treated with caution.

Of the sediment samples collected in 2000 that were not spacially coincident with the 1999 sampling, four were collected to the South of Silvermines village and two to the south of Magcobar open pit. Although a description of each site is not provided, there was considerable variation in metals content between samples collected within ~1.5km of each other. South of the Silvermines village, the southernmost sample taken just north of Knockanroe had the lowest Pb content (51 mg/kg) but the highest Mn and Co contents (28261 mg/kg and 109 mg/kg respectively) and elevated Fe (51493 mg/kg). Moving north, the Pb contents increase towards Silvermines village with 1695 mg/kg Pb found just south of the R499 road. Other metals are also elevated at this site, e.g. Cd was 7.7 mg/kg and Zn 1661 mg/kg. Uranium, Th, Ba, Sn, As, Cu, Co, Ni, Cr and V were also detected at most of these sites. South of the Magcobar pit the metals contents were generally slightly higher than those seen at Silvermines although Pb levels did not exceed the value of 1695mg/kg observed at Silvermines village.

The three other samples collected in 2000[106] were collected from the Yellow River, on the south side of the Garryard mining complex and from a tributary on the northern side of the Magcobar open pit. The sample collected north of Magcobar pit was coincident with site SS3 sampled in 1999[87] and one of the samples on the Yellow River was coincident with site SS2. The third sample was taken upstream of the latter sample, adjacent to the Garryard mining complex. Relative to the 1999 data, the metals concentration recorded in 2000 are elevated, although detection limits between the sampling episodes were different. For instance, in 1999 the detection limit for U and Ag were both quoted as <1mg/kg but in 2000, <6.3mg/kg and <314 mg/kg were quoted respectively. In 1999, 2.6mg/kg Cd and 817 mg/kg Zn were detected at SS3, while in 2000 10.9mg/kg and 2336mg/kg were detected. The sample collected upstream of site SS2 contained the highest levels of Pb (46943 mg/kg), Sb (239 mg/kg), As (1562 mg/kg), Zn (19194 mg/kg) and Fe (149150 mg/kg) observed in 2000.

In summary, stream sediments generally contain elevated metals contents within the vicinity of former mine workings, although elevated values are also found elsewhere. The dispersion is controlled by the water chemistry, which tends to result in metal precipitation only a short distance from the mining areas.

5.7 Groundwater

5.7.1 The natural groundwater regime

Very little detailed groundwater information has been collected in the Silvermines area and the following conceptual model has been derived from the work done for the Magcobar EIA, discussions with Geoff Wright at the Geological Survey, Olga Aslibekian and our own experience and observations. The hillside comprises largely the Devonian sandstones and the lowlands are underlain by the limestones. The orebodies are on the Silvermines fault area between the two lithologies.

Structurally, the area is at the western end of the Kilmastulla syncline and the geological units are shown on Figure 5.4b.

The groundwater potential of the various lithologies in the area has been classified in terms of groundwater protection zone studies. Broadly the Lower Carboniferous Waulsortian limestone has been classified as a regionally important aquifer. The Ballysteen limestone formation is a locally poor aquifer and the Silurian and Devonian formations are regarded as regionally poor aquifers. The hydraulic characteristics of the main aquifers will be based on secondary permeability and storage although these will be enhanced by weathering to primary and secondary hydraulic characteristics in the weathered zone. There are regionally important faults which probably comprise hydraulic barriers due to the offset of formations.

The Magcobar pit and underground workings did not have high groundwater inflows but the adjacent Mogul mine had the highest flows (11,000 to 13,000m^3/day according to Daly 1994) indicative of high permeability and possibly some karstic features enhancing secondary permeability. During operation the pit was pumped for less than one hour a day in summer, suggesting that the groundwater inflow rates were very small (B.J.Murphy & Assoc.1999). The Waulsortian is known to be subject to karst formation and can have locally very high hydraulic conductivity.

Verbal communications and have reported groundwater levels in the various mine workings along the sub-crop area are of the order of 20 to 30m below ground surface, but this has not been confirmed, and requires further investigation.

B.J.Murphy & Assoc. (1999) report depths to ground water in the Macgobar pit area of 10 to 30m below ground level depending on the surface elevation of the borehole. It is likely that mining has had a levelling influence on ground water levels across the area in the immediate area of the workings. Groundwater levels in the Carboniferous limestone areas across the lowland are usually within a couple of metres of ground surface.

It should be noted that there is a very active interflow zone providing seepages and springs across the higher hillsides. It is assumed that these are 'perched' and not part of the true groundwater system.

From the above it is assumed that groundwater flows would normally be following a subdued form of the surface topography and drainage would be northwards to the Kilmastulla River.

5.7.2 The influence of mining on the groundwater regime

During active mining the influence on the groundwater system will be significant. After mine closure, groundwater usually recovers close to the original levels but there will still be residual influences.

Mine water is known to discharge at the Mogul shaft and the drainage adit from Ballygown mines. This may artificially depress the groundwater levels at the sub-crop. Without the shafts, groundwater would be partly confined below the lower permeability carboniferous formations and recover to a higher level.

Mining will also change the surface infiltration characteristics in the mine area especially if subsidence has been induced and if the surface vegetation has been replaced by bare soil or rock. This will be considered during the Phase II study.

The most significant long term impact will be on the water quality both from infiltration through surface waste materials on all the sites and from flow through underground workings especially in zones of oxidising sulphides.

5.7.3 Groundwater quality

Due to a lack of intrusive investigations, background or upgradient groundwater quality is largely unknown as are the potential impacts from historic anthroprogenic activity, including mining and agriculture. The need for additional drilling will be considered in Phase II.

Groundwater was encountered in underground workings at Mogul during a study of the geothermal gradient by Minerex Ltd. (1982)[43]. It was considered that all water encountered was interflow from surface rather than groundwater. The water had a temperature of 10.8°C and an EC of 574 mhos/cm.

As part of the Minerex study, samples of water from the mineralised K zone were taken, although the exact sampling location is unknown. These samples had pH of between 5 and 6, low Total Suspended Solids (TSS) (<5mg/l), Total Dissolved Solids (TDS) ~100-300mg/l and alkalinity between ~50 and 170 mg/l $CaCO_3$. Metals analysis indicated elevated Zn in a number of samples (up to 3.6mg/l) but Fe, Pb and Cu concentrations were generally <0.05mg/l.

A more comprehensive survey of groundwater was undertaken as part of the EIS at the Magcobar open pit in 1998. The study comprised drilling 17 boreholes, 11 (RC-1 to RC-11) around the open pit and 6 (BH1-BH6) on the water in the pit. Boreholes drilled on land were finished with 20mm slotted standpipes. Some test pumping and permeability testing was carried out and showed low yields and low permeability. Water quality data is only reported for holes RC1, RC3, RC7, RC8, RC9 and Well 2.

Unlike other water samples collected as part of the EIS, pH and EC are not reported for the groundwater samples. The groundwater was hard, with total carbonate hardness ranging between 225mg/l $CaCO_3$ at RC 9 and 1045mg/l $CaCO_3$ at Well 2. A similar spatial distribution is observed for SO_4, with 91mg/l at RC 9 and 822 mg/l at Well 2. Like the surface waters encountered around the Magcobar area, a range of trace metals were detected in groundwater. At all sites, Mn, Fe, Ni, Zn, Sr, and Ba were detected. At all sites apart from RC 3, Cu and Pb were also detected. Chromium, Ti, Cd, As, and Sb were detected in a number of samples. Uranium was detected (0.002mg/l) at Well 2 and Th (0.003mg/l) at RC 8.

There are some shallow wells in the area for water supply, but the extent of use is not known. Water supply for Silvermines Village is 50% from the regional water supply and 50% from a treatment plant taking water from the Silvermines Stream upstream of the calamine mine. At the end of September 2001, the village supply will come entirely from the regional supply. Mogul operated some wells 2km west of the site which had yields of around 30 to 80m^3/hour (B J Murphy, 1999). One of these wells is now used by the Shallee Private Water Scheme, which supplies water to local farms.

5.8 Vegetation and Habitats

5.8.1 Information sources

Published information sources are listed in the references (Appendix A). Further information was obtained by local consultation, site examination, and consultation with Dúchas and DMNR (EMD and the Geological survey of Ireland (GSI)). Data on revegetation of the Gortmore tailings was collected by Mike Johnson (Liverpool University) and by Pat Timpson and co-workers (Sligo Institute of Technology, see references). This was not examined or discussed due to time constraints during Phase I, but will be addressed in Phase II. Anecdotal information is reported but has not been checked unless stated.

5.8.2 Ecological Areas

The following broad types of vegetation cover and habitats occur in the Silvermines area of investigation:

(1) Improved agricultural grassland, receiving fertiliser, slurry or farm yard manure (FYM) inputs, used for pasture for dairy cows, suckler and beef cattle, sheep and horses, and for silage and hay production. Impacted by tailings dust (in the 1980s), dredged drain spoil, flooding, traffic of mine vehicles (during mine operation), and possible run-off from contaminated waste. [DAFRD, 2000; Finch and Gardiner, 1993[61]; O'Meara, 1985[51]].

(2) Unimproved grassland, used for rough grazing by cattle and sheep, not receiving fertiliser, slurry or FYM inputs (mostly occurring on the podzolic and peaty podzolic soils of the upland area). Some of this area is directly contiguous with pit overburden dumps and old mine spoil areas.

(3) Cultivated and horticultural land (incl. gardens) used in particular for human food production (potatoes, vegetables, fruit). Of particular concern in Silvermines village. [DAFRD, 2000[87]].

(4) The Kilmastulla River system, with its salmonid fishery downstream, including tributaries (including the Shallee River, Silvermines River, Foilborrig River and Yellow River) streams and drains. Many tributaries associated with the mine areas, in particular the Yellow River, have been contaminated by drainage through and run-off from mine waste dumps and lagoons. This has resulted in pollution events locally and downstream.

[Bracken *et al*., 1991[61]; Quirke, 1998[71]; DAFRD, 2000[87]; Aslibekian *et al*., 2000[90]; McCarthy and Breen, 1999[81]; Neill and Lucey, 1980[41], 1981 O'Reilly, 1993[62]; Kurz and Costello, 1999[80]].

(5) Metalliferous ecosystems associated with mine waste, including seeded and naturally vegetated tailings, naturally vegetated spoil and rock waste, and mine wetlands. These areas provide valuable clues for successful self-sustaining vegetation cover. [Durkan, 1985[52]; Timpson, 1991[42]; Boland, 2000[89]; Steinborn and Breen, 1999[85]; Good, 1999[78/79]a,b; McCabe and Otte, 2000[96]].

(6) Contaminated land supporting very poor or no vegetation cover, due to toxicity or physicochemical difficulties associated with the contaminated substrate. These areas include, amongst others, the Garryard old stockpile area (south of the road), the drum dump at Shallee, the tailings lagoon at Garryard (north of the railway line), the Gortmore TMF unvegetated tailings, the clinker waste and tailings at the Ballygown area (south of Silvermines village), and the bare tailings at Shallee. They are of particular concern due to their high level of actual and potential impact. [DAFRD, 2000[87]; EPA, 1999; Arthurs, 1994[63]; Boland, 2000[89]; Natural Resource Consultants, 2000[86]].

(7) Old buildings, mine shafts, pit rock cliffs and underground workings, potentially used as roosting or nesting sites by bats and peregrine falcons. [McAney, 1999].

(8) Associated land cover and uses in the area not impacted by mining activity, but possibly relevant to rehabilitation as a source of materials. This includes, amongst others, conifer forestry (a potential source of brash), non-designated wet grassland and other wetlands on gley soils (as a source of soil cover), and road-works spoil/topsoil from improvements to the N7 (as a source of soil cover).

Zones within the area of investigation are described in Table 5.9.1 Appendix C. Sub-zones are described in Table 5.9.2, Appendix C. There is insufficient map detail available at present to produce a reliable map of these zones. This will be produced for the Phase II report.

5.8.3 Contaminated agricultural grassland

Results of detailed investigations into agricultural grassland, dairy and suckler cows, and beef cattle, are given in DAFRD (200087). Two farms (Farms A and B of DAFRD (200087) report), where animal deaths occurred due to lead toxicity, are of particular concern. The sources of contamination are different in these two farms. In the case of Farm A, the source of lead is not certain, but one possibility is that it originated from contaminated silage from fields with soil lead concentrations of up to 16 450 mg/kg (DAFRD, 200087). Another possibility is a hot-spot within the field that the cattle were turned into. There is no evidence of dust-blow from the Gortmore TMF to this field during 1998-99 (ibid.). In the case of Farm B, the source of lead was probably stream sediment (ibid.) in the stream receiving runoff from the Garryard old stockpile (south of the road).

Lead values in some of the stream sediments are very high and ingestion by cattle could result from drinking stream water and stirred sediment or ingestion of sediment deposited in the fields from flood flows.

Even where the main mining sources of contamination are controlled, there remains the probability of continuing forage contamination from soil heavy metals. There are a number of rehabilitation options for contaminated agricultural grassland including:

- management practices (e.g. land rolling and care in mowing machine setting to avoid soil contamination of silage);
- hot-spot identification and exclosure in fields, and:
- a change in field or field-plot use out of intensive grass production (possibly involving topsoil stripping for cover material for mine waste).

Best options for remediation and management will be identified in Phase II

The consultants are grateful to landowners in Farms A and B, who kindly provided their time to explain the circumstances of their livestock problems.

5.8.4 Designated Areas

There are no areas designated, or proposed for designation for species or habitats requiring legal protection. (Special Conservation Areas (SACs); Special Protection Areas (SPAs); Natural Heritage Areas (NHAs); Statutory Nature Reserves under the Habitats Directive (S.I. 94 of 1997); Birds Directive (various S.Is.); Wildlife Acts (1976-2000). There is an SAC (no. 939) south of Silvermines village in the upland part of Silvermines, designated for *Nardus* grasslands and dry and wet heathlands, but this is some distance from, and upstream of, the mine sites. However, calaminarian grasslands (open semi-natural grasslands with a specialised flora on old terrils or spoil heaps around mines) are listed as a non-priority habitat for protection under the Habitats Directive. Some of the metal-tolerant vegetation which has naturally recolonised the mine spoil and old tailings areas should be botanically surveyed before being disturbed by rehabilitation works, especially if this is to form part of a nature trail for the Heritage Centre. This will be further investigated in Phase II.

5.8.5 Gortmore TMF: Vegetation cover and dust-blows

A series of major dust-blows from the unvegetated tailings beach in the mid-1980s have been well documented in the local press (Table 5.9.3 Appendix C). A photograph of one of the 1984 blows (at the tailings margin) was published in the *Nenagh Guardian* (Gleeson, 1984). There was extensive dust contamination of surrounding agricultural grasslands, to the north of the TMF in summer, and to the west and south of the TMF in winter. Since vegetation cover was established, there have been no major dust-blows, but the local farming community are highly concerned that there could be a repeat of the 1980s events if the vegetation cover of the tailings is degraded. The degraded margins of the TMF are of particular concern. Much of the north-east zone of the tailings surface has degraded areas with no living vegetation cover (Table 5.9.2. - Appendix C). There are large areas where vegetation has been degraded. However, a surface crust of algae and moss appears to limit dust blow potential, provided it is not broken up.

5.8.6 Gortmore TMF: Self-sustaining soil/vegetation cover

In areas where vegetation appears to be good and possibly self sustaining, the 'do nothing' option may be acceptable. In areas which are devoid of living vegetation or where the vegetation is weak then a number of options are possible, to create a self sustaining cover. Depending on geochemistry, the options may include:

- surface lime application with organic matter amendment;
- soil or soil substitute cover;
- treat certain areas with a cheaper cover, and then treat 'hot-spots' of vegetation degradation with a more expensive solution after say, five years, when they appear, and;
- establish windrows.

Other temporary options, such as covering margin slopes with forestry brash to reduce wind penetration, may be necessary while trial work confirms or corrects a long-term solution.

The options described are notional, and may change when more detailed data and costs become available.

Currently, there are conflicting risks in the management of the tailings vegetation cover. On the one hand, there is the risk that if short term action is not taken, a dust-blow event may occur before rehabilitation of the degraded areas can prevent it. On the other hand, there is the risk that if a rehabilitation option is implemented too quickly, without appropriate trials of alternatives, the option may not succeed.

There are further technical risks associated with the above. For example there is the risk of degradation of some areas of grass cover if fertiliser (10.10.20 NPK) is not applied to maintain it. Unfortunately, excessive fertiliser application can create conditions where the metal-tolerant decomposer and nutrient recycling biological communities in the soil can be degraded, leaving a system either dependant on perpetual fertiliser use, or more susceptible to degradation once fertiliser application is stopped.

Risks such as these need to be identified and quantified in the context of the different zones of the TMF. The south-east zone and parts of the south zone, for instance, may require no fertiliser application for the most part, if their cover is self-sustaining. The location of risks can then be mapped before decisions are made (to be carried out in Phase II).

Quantification of these risks and their costs will require, *inter alia*, the following :

(1) A detailed confirmation/correction of the zones on the tailings surface, with their acreages, and identification of hot-spots within each zone.
(2) A review of meteorological records (already begun in Phase 1) relevant to both the winter and summer dust-blows, to estimate the probability of dust-blows expected to occur in the recent past (e.g. last March (2001) during easterly winds), if dust-blow was a high risk.
(3) Costing of cheap temporary solutions (e.g. brash cover on tailings margin slopes).
(4) Costing of more expensive long-term solutions (topsoil or topsoil substitute haulage, transport over tailings and spreading).
(5) Self-sustainability assessment of vegetation in zone for which the 'do nothing' option may be preferable (see Good, 1996).
(6) An assessment of risks associated with altering the surface hydrology of the tailings to promote surface water retention and wetland cover, as opposed to surface drainage to promote dryland cover (the latter being difficult due to the poor drainage through the silty-textured tailings mass).

If soil or soil substitute cover is deemed to be necessary, solving two problems at the one time should be considered wherever possible, to reduce costs. For instance, If patches of marginal agricultural grassland topsoil are considered to be high risk for grazing because of heavy metal contamination, these could be used as a topsoil source for the tailings. A further option is excavating topsoil from marshy areas and wetlands of low agricultural productivity near the TMF, in such a way that the Yellow River or the Kilmastulla River can be diverted into the excavated wetland to act as a trap for contaminated sediment. Spreading contaminated sediment from the streams and drains may also be an option especially if the material contains organic matter. This would depend on levels of contamination and the proposed after use. Waste materials from forestry operations or peat-cutting may also be useful. The viability of any of these options will only be clear after conceptual design and costing.

5.8.7 Further information sources and requirements

Due to time constraints and FMD restrictions, a number of sources of information are yet to be investigated: Sligo IT research work; EPA and TNRCC open files; Teagasc data; University of Limerick research work; fauna (bats) and flora (metallophytes and scree flora) records; reports on the proposed heritage site at Shallee. It is anticipated that data from these sources will be available during Phase II.

A list of plant species of particular importance in self-sustaining vegetation cover has been started in Table 5.9.4, Appendix C. This needs to be developed further. Further questions arising, relevant to revegetation, need to be addressed (Table 5.9.5, Appendix C). Finally, biological impacts additional to those listed in Table 5.9.6 need to be listed (to be carried out in Phase II).

5.9 The mine workings

5.9.1 General

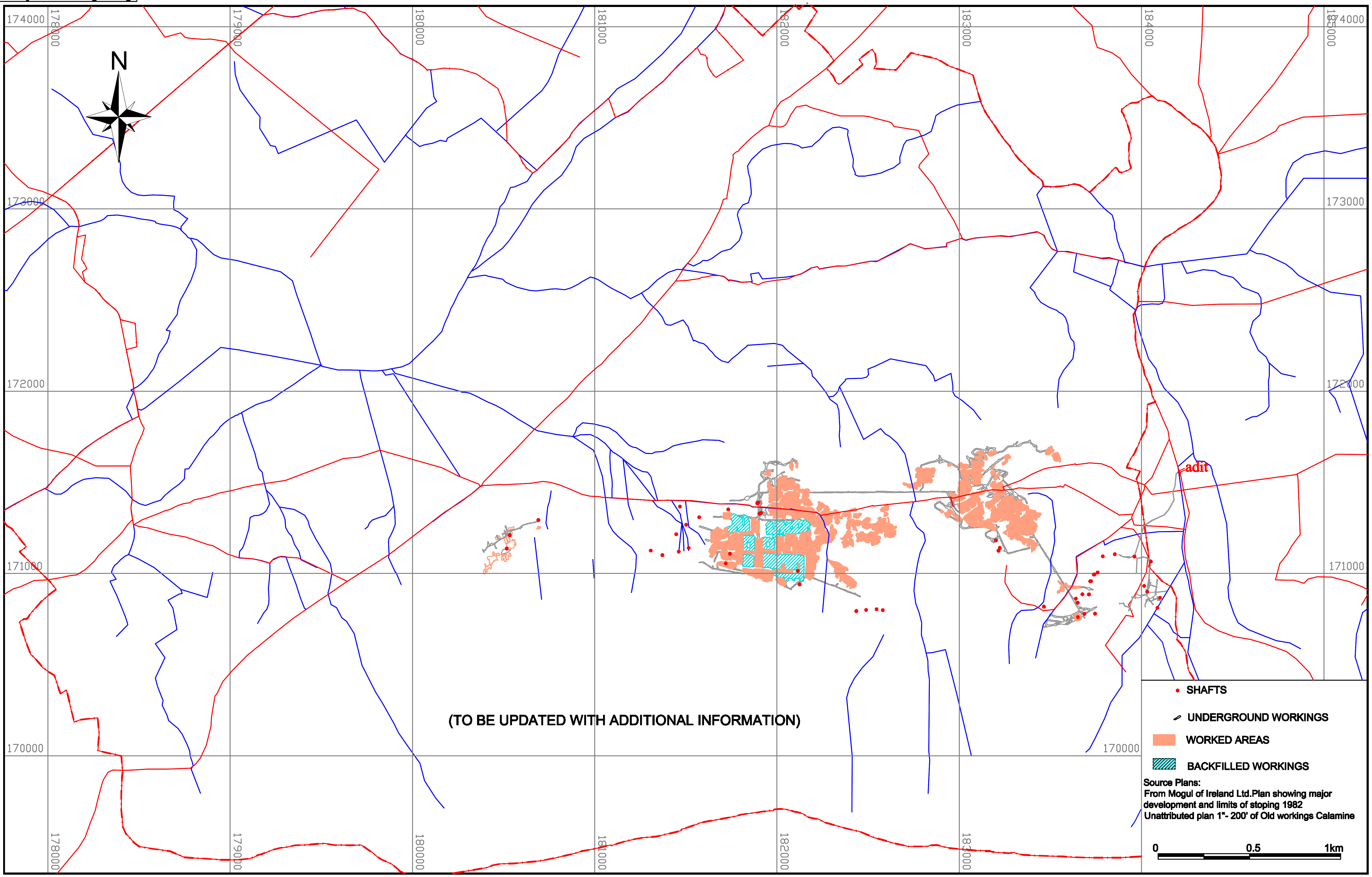
As a result of the intensive mining activity, underground workings, open pits, spoil heaps, tailings ponds and other mine wastes are located mainly along the northern slope of the Silvermines mountain (Figures 4.1 and 5.8). These cover an area of approximately 5km^2.

5.9.2 Open Pits

The Magcobar open pit is by far the largest opening and although well fenced, constitutes a potential hazard due to deep water and possible side slope failure or erosion in the longer term which could extend beyond the fencing.

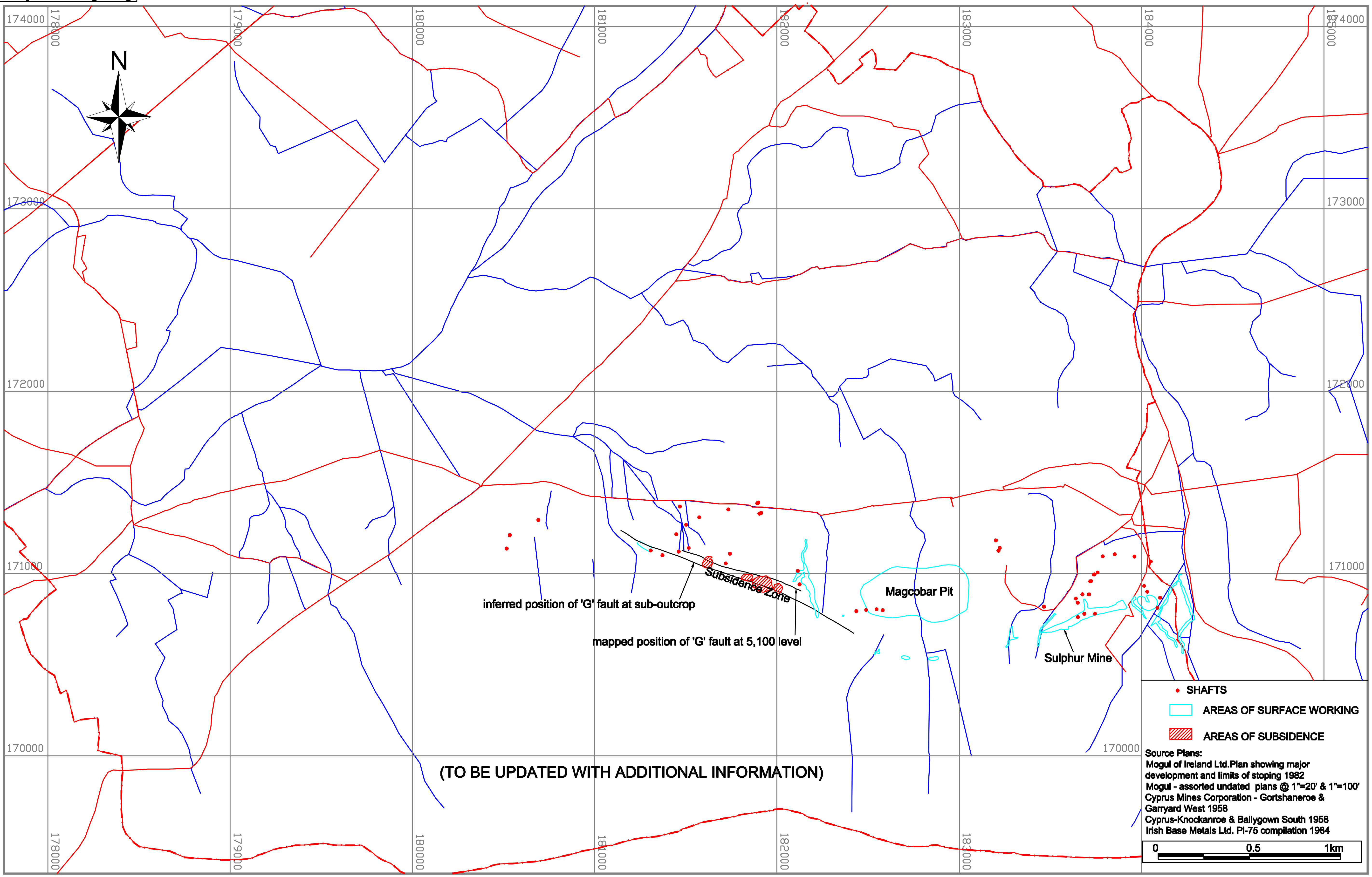
The Shallee workings are a combination of open pit and shallow underground workings with some vertical shafts. A geotechnical study has been done on part of the workings in connection with the proposed heritage site but there are areas of considerable hazard which will need to be made safe. For example, there is one vertical shaft with a steel grid but the gaps between the girders are sufficiently wide for a child or animals to fall through.

Graphics\U1606\Fig5.8.dwg



APRIL 2001	PROJ. No: U1606	SILVERMINES	Scale 1:20,000
SRK Consulting Engineers and Scientists		PLAN OF UNDERGROUND WORKINGS	Fig 5.8

Graphics\U1606\Fig5.9.dwg



MAY 2001	PROJ. No: U1606	SILVERMINES	Scale 1:20000
SRK Consulting Engineers and Scientists		PLAN OF SURFACE WORKINGS, SUBSIDENCE AREAS AND SHAFTS	Fig 5.9

5.9.3 Subsidence of mine workings

The Mogul mine site is characterised by large collapse features due to shallow undermining. These have not yet been inspected or evaluated, and will be dealt with in Phase II.

The location of existing surface subsidence is shown on Fig. 5.9.

5.10 Surface structures

The key elements are discussed in this section.

5.10.1 Openings, vents, shafts and declines

There are a significant number of vent and access shafts in the Ballygown area on Calamine and Knockanroe. Many of them are closed either by collapse or backfill but only one was observed to have a concrete cap. The structure of the cap is not known but it is not likely to be substantial. The vent shafts along the drainage adit appear to be backfilled but the nature of the backfill is not known. Some of these shafts are within the Silvermines village and their positions need to be clearly identified and the possible hazard of collapse assessed. It is understood that during heavy rains, water discharges from the shaft in the field immediately north of the new school playing field. In the longer term, erosion can cause undermining of the backfill.

There are a number of shafts which are open. Most have a fence around although these are generally in poor condition. It is considered that prompt action should be taken to make safe the shaft at Shallee mentioned in Section 5.9.2, a shaft at the Sulphur Mine with a damaged fence, the Shallee opencast workings and the subsidence area. In each case there is at present relatively unhindered public access and, in most cases, the action will be the placement or repair of damaged fencing, warning signs and, possibly, the prevention of unauthorised access to the general area.

5.10.2 Mine buildings

The Calamine site has two stone buildings that are in ruins but may be of industrial archaeological interest.

The Knockanroe site has the most recent plant buildings to the south of the school. The main buildings are part concrete and part steel frame and steel clad in poor condition. The roofs are asbestos cement cladding. There are also a number of foundations for heavy machinery and conveyors which appear to be mass concrete rather than reinforced. The buildings have been recently used by a farmer for cattle and horses.

The Magcobar site has:

- A crushing plant now in poor condition and which is very visible;
- A large core storage shed and workshop which is a steel framed, steel clad building in generally good condition;
- Two large steel fuel storage tanks one at the core shed and one at the crusher;
- A prefabricated office building near the main gate.

The Mogul plant site is the largest of the structures in the area and comprises all the elements of a metal processing plant within a largely concrete paved area. The majority of the buildings are steel framed and steel clad and in fair condition. The front end of the process structures include reinforced concrete pads, bins and two large concrete tanks.

The site is currently occupied by a road haulage contractor who is doing some refurbishment of the buildings for garaging and maintenance workshops. No consideration appears to have been made of the potential contamination of the site or of possible further releases of contamination due to earthworks and construction. It can be noted that the occupier is constructing a vehicle washdown pad adjacent to the mine shaft water discharge. This discharge feeds directly into the larger of the ponds to the north of the site. It is considered that the influence of the new works is small in relation to the existing levels of pollution in the pond and lagoon.

SRK understand from discussions on site that the ponds have been purchased by the farmer immediately to the north of the plant site.

The Shallee site has a number of structures that appear to relate to various phases of mining. They include:

- A derelict and ivy clad stone engine house and chimney;
- Various mass concrete foundations for the crusher;
- Large nissen type buildings for core storage;
- Stone buildings for core storage and offices in poor condition;
- The shell of the double storey King house;
- A laboratory building with many (empty) glass chemical bottles;
- An office building near the main gate.

These are discussed in detail in the report on the proposed development of the Shallee mine as a heritage site. The findings of the report will be reviewed in Phase II.

5.10.3 Tailings deposits

There are two areas of formal tailings deposition, namely at Shallee South/East (north and south of the road) and at Gortmore (the GTMF) which was developed for the Mogul mine. The largest of the ponds (north of the railway line) at Garryard was a settlement pond for water and process slurry discharged from the plant, and is classified here as a tailings lagoon.

The tailings facilities at Shallee and at the Garryard plant site were sampled by the EPA in September 1999. Teagasc also undertook sampling of the tailings at the GTMF as part of their investigation. Eight samples were collected from GTMF, six from Garryard and three from Shallee. This data is supposedly reported in Appendix 3 of the IAG report, although the full data set for the GTMF appeared to be missing. Additional sampling was undertaken in October 1999 as part of the assessment into the proposed National Mining Heritage Centre at Shallee. A summary of the results for the three mine areas is given in Table 5.2.

Table 5.2 Metals concentrations in tailings (mg/kg)

Metal		GTMF	Garryard	Shallee
Pb	Range	2609-15540	14085-51230	3240-3843
	Mean	8314	32498	3512
Zn	Range	2560-10990	45047-94458	101-267
	Mean	6747	75509	197
Cd	Range	1.48-46.48	169-327	0.4-1.6
	Mean	19.65	266	1.2
As	Range	110-1060	331-1292	83-251
	Mean	427	676	158

At the Garryard, site four sediment samples were collected from the tailings lagoon and two from the settlement pond. All sampled sites had elevated metals with Pb was between 14000 –50000mg/kg, Zn 45000-95000mg/kg and Fe 86000-233000mg/kg. Numerous other metals were also detected including Cd, U, Tl, Sb, Ag, Mo, As, Cu, Ni, Co, Cr, V and Al. Analysis of the water from the settlement pond and tailings lagoon at Garryard indicated Pb concentration up to 0.37mg/l, Fe 3.3mg/l and 2.7mg/l Zn. Water pH and alkalinity were not reported. During the SRK site visit, site measurements of pH, conductivity and temperature were taken. The settlement pond showed conductivity ranging from 1100 to 1300µS, pH of 8.1 and temperature of 12 to 14^{o}C. The tailings pond discharge conductivity was higher than the capacity of the device, but the pH was 7.6 and the temperature was 15.9°C. The discharge flow was estimated at about 60m^3/h.

There were a number of small ponds of poor water around the edge of the main pond on the surface of the TMF. These showed a pH of 2.3 and conductivities higher than the capacity of the device. It is clear that the metal content of the Garryard tailings lagoon is significantly higher than the formal tailings facilities at Gortmore and Shallee. In comparison to Garryard, Pb concentrations in the tailings at Shallee did not exceed 4000mg/kg, Fe 30000mg/kg and Zn 300 mg/kg.

At the GTMF, Pb concentrations vary across the surface of the facility and are elevated in relation to the levels permissible for agricultural use or grazing. The variation in the chemical results reflects the heterogeneous depositional history, which in turn represent different phases of mining. As the ore contained varying degrees of pyrite, so do the tailings. In addition to chemical variability, the tailings also show a variation in particle size distribution. Coarse particles are deposited on the edge while silt and clay-sized particles are found in the centre.

In addition to the high metals concentration in the tailings, the tailings facility have also been considered a source of dust. During the period 1984 – 1987 evidence for dust blow from the GTMF was gathered. The most severe dust blows occurred in February 1985 (Mogul, 2000). Following these dust blows, directional gauges were deployed in 1986-1987 which were aimed are measuring the flux of dust moving through a vertical plane in a given direction.

No mention of dust monitoring between 1987 and 1999 is made in the IAG report. However, in March 1999, a dust deposition monitoring programme was commenced. This was in response to local concerns regarding the potential for dust blows from the GTMF. The data gathered in this study is not comparable to the earlier dust monitoring as the latest study measured the concentration of dust deposited through a horizontal plane and settling on the base of a sampling jar. This sampling was conducted at four locations at each point of the compass and within 10- 15m of the TMF mound. Following establishment of the IAG, this monitoring was extended to a further 12 locations where dust was monitored on a monthly basis. The dust collected was analysed for Pb, Cd, Tl, Zn and Fe. These results are reported in Appendix 3 of the IAG report. There was no distinction in size fraction made. The main conclusions of the dust monitoring were that there was a localised effect of elevated concentrations of metal dust within 20m of the GTMF.

Since seeding of the GTMF in 1987 there is no record of serious dust blow events. A monitoring and emergency plan was developed and is currently in place should the situation change. The Monitoring and Emergency Plan is given in the IAG Report. It is considered that, at present, the surface vegetation and the hard surface crust is such that dust blows will not occur. The monitoring programme will give indications of any deterioration in the state of the surface, allowing remedial action to be taken, and avoiding the implementation of the Emergency Plan. It is considered that the proposed emergency procedure, involving the use of a tractor and water tanker on the surface of the tailings, has severe disadvantages, as any disturbance of the surface by the vehicle tyres will break the crust, and increase the potential for dust generation. Information has been received on the original rehabilitation process and SRK has the authorisation from Ennex to obtain further information from Pat Timpson of the Sligo Institute of Technology in terms of the rehabilitation test work and monitoring results on the TMF. This information will be gathered during Phase II.

The TMF was inspected thoroughly during the site visit and the present status assessed. Key issues at present are:

- The limited seepage of ARD from the toe of the TMF;
- Areas with no grass cover especially on the north side;
- High moisture content near surface and low strength near the centre part of the TMF;
- Potential dust blow;
- Erosion and escape of contaminated water to the Kilmastulla River.

Areas without grass often show an algal or moss growth which stabilises the surface and appears to prevent dust blow. Provided the surface is not disturbed, dust blow should be minimal under normal conditions. This could change if the surface dries out or is broken by extensive frost heave or mechanical or livestock movement.

On the other hand, improved grass growth may be achieved if the drainage of some areas is improved.

5.10.4 Waste rock dumps

Waste rock exists at all sites in small scattered piles and sometimes includes high sulphide rock. Magcobar has large, formal waste rock piles in five separate locations around the pit. These have an obvious visual impact which is reduced by good natural vegetation cover on many of the side slopes. Recent extraction of rock from the toe of one of the dumps and aggregate crushing in other parts have exposed the bare rock spoil, creating a visual impact and potential instability.

Again, there is often highly pyritic material which has resulted in seepages of ARD. This material is observed to have been placed on the tops of dumps in specific areas, suggesting that it will be relatively easy to deal with. There are no indications of significant acid drainage from within the body of the dumps.

Drainage from individual waste rock dumps has not been characterised. Similarly the reactivity of the material and the potential to generate Acid Rock Drainage has not been assessed. In most cases the observed impact can be seen locally or in the chemistry of the nearest stream.

An area of importance is the Garryard old stockpile area immediately north of the Mogul plant site, on the other side of the main road. Although small, this area has been used to dump various mine wastes subsequent to it use as a stockpile, and in particular, concentrate spillage from the process plant. A surface inspection showed a variety of processed material, massive sulphide boulders and smaller rocks, together with general waste. There is no specific information on what has been placed here. The farmer who owns this land has been moving material in order to prepare the land for agricultural use.

5.10.5 Ponds and lagoons

The important sites comprise:

- The flooded small pit at Ballygown
- The flooded Magcobar pit
- The settlement pond and tailings lagoon at Garryard;
- The flooded open pit workings at Shallee;
- The tailings pool on the GTMF, and;
- The old return water ponds at the GTMF.

The Magcobar pit water quality is dealt with in Section 5.5.4.

The settlement pond south of the railway line at Garryard receives run-off water from the old Mogul plant area. The water, vegetation and reed growth appears good but there is little sign of water life. The tailings lagoon to the north of the railway line receives water from various streams mainly from the plant site, including discharges from the mine shaft. Field indicator measurements suggest that there is significant variation in the quality of the influent water. The ponds of water in depressions in the sediments and the main pond discharge are deep red in colour and have very low pH. Water in the main pond appeared to be gassing freely which is presumably hydrogen sulphide due to sulphate reduction.

The flooded open-pit workings at Shallee and the small pit at Ballygown will be investigated during Phase II.

The water quantities and qualities need to be carefully assessed to ensure optimal closure planning for this pond. This will be carried out during Phase II.

5.10.6 Scrapped equipment, metals, containers, and other wastes.

The majority of scrap equipment and other waste materials is on Shallee South/East with a small amount on the Mogul plant site and the Magcobar site. There are some small scrap piles scattered around the Ballygown sites.

A key concern is the steel drums which have been extensively dumped at Shallee on surface and in the pit ponds. It is also understood from local residents who worked at the mine that many of these drums contained sodium cyanate and that some drums were placed in the underground workings at Mogul and were not recovered on closure. Further information will be solicited during Phase II.

The dumps of metal and general scrap and waste at Shallee are quite extensive and will require collection and formal dumping and protection. In places the dumped material shows seepages of highly contaminated water issuing from the toe and draining into a ditch which then crosses the adjacent field. This will be investigated during Phase II.

5.10.7 Industrial archaeology

This will be discussed in the Phase II report, after the inspection by the industrial archaeologist. There are mine structures of historical interest in the study area, and the development of a mining heritage site has been proposed for Shallee Mine.

5.11 Summary of omissions from the available information

The review of Phase I has involved the examination of documentation and maps in the DMNR data room, but also material collected from mine owners, academic institutions and other sources. Certain gaps in the information have been identified. The collection of information is continuing, and it is probable that some of these gaps can be filled using existing data not yet retrieved.

Table 5.3 lists important additional information which is required for the conceptual design of the management and remediation of the Silvermines area. The gathering of this information will form part of the Phase II site investigation. An important item which was not determined in the scope of work was the extent of any additional sampling and chemical testing. This is dealt with in detail in Section 8.7.

Table 5.3 : Information to be Gathered to Supplement the Available Information

INFORMATION	PROCEDURE	COMMENT
Pollution contributions from small stream tributaries, lagoons and dumps.	Field sampling programme	Full details in Section 8.7
Acid drainage from Gortmore TMF	Field sampling programme	
Groundwater quality and flow characteristics	Sampling of shafts and adits where possible; conceptual modelling of groundwater. Drilling programme	Magcobar boreholes blocked or dry, other sampling points limited
Flow information for tributary streams	Catchment run-off calculations	
Locations of shafts, cavities, pits and ponds	Plotting of available additional information from plans	Certain may require further investigation.
Vegetation survey	Walk over surveys	
Revegetation trial results on GTMF	Obtain from Sligo Institute of Technology	

6 HAZARD IDENTIFICATION

The risk management approach to rehabilitation examines possible sources of impact on the environment using a source-pathway-receptor framework. This constitutes identifying the hazards, the pathways and the receptors and assessing the sensitivity of the receptors. The options for remediation can then be considered. The tables must be considered as a preliminary evaluation and no measure of risk assessment is presented at this stage. The tables will form the basis of the project evaluation and will be developed further in Phase II.

It should be noted that although the following items focus on possible contamination aspects, there are other impacts that will be considered and are summarised in the discussion below.

The key aspects for each of the individual sites visited to date are summarised in tables 6.1 to 6.5 at the end of this section. These tables will form the basis of the assessment and will be progressively modified and expanded in detail in phases II and III.

The following sections discuss some of the main hazards listed in the tables.

6.1 Stream pollution

Fairly extensive data is available on surface water sampling downstream of the mining sites. There is limited data on the more detailed surface streams and water sources within the mining areas and this will have to be improved to enable an integrated remediation system to be assessed (to be done in Phase II). The results show varying degrees of contamination over a significant part of the Kilmastulla catchment above Cranna Bridge and to the south.

Some control sampling will be required to provide a complete set of analyses as many of the available information focuses on certain elements. Mercury for instance has not been analysed. This control sampling and testing will be carried out in Phase II.

The sources of stream pollution are complex and include leaching from mine wastes, erosion of particulates, dust blow and elevated metals from natural sources.

Flood events then cause further contamination of soils by mobilisation of sediment.

6.2 Groundwater quality

Very little information exists on the ground water system and groundwater quality in particular. Historic mining practices will almost certainly have impacted on groundwater because there has been no protection for infiltration to groundwater. It would be very expensive to carry out a full investigation to characterise the groundwater system but some drilling should be carried out to enable a preliminary characterisation to be done.

Remediation of surface works will be beneficial in terms of improving ground water quality. An understanding of the groundwater system will enable the benefit to be assessed and will also identify if there are any specific recommendations for management of ground water in the future. Remediation decisions for the Gortmore TMF may however be more closely linked with the ground water system and it is necessary to investigate the groundwater system in the immediate area of the TMF as soon as possible to integrate remediation recommendations.

It is understood from local residents that no groundwater is used locally for domestic purposes but further investigations are required to identify existing wells that may be sampled.

The main concern would be contamination of the Waulsortian limestone which is a local and regionally important aquifer. It is possible that infiltration rates from the various surface and underground sources may be sufficiently low to be diluted within any important aquifer.

The groundwater uncertainties will be addressed in more detail in Phase II.

6.3 Land contamination

Contaminated land comprises areas of mine waste and former processing activity, areas where flooding has deposited metal bearing sediment particularly on the flood plains and areas affected by dust blow.

Contamination will comprise soils and vegetation uptake of metals. There is a significant set of data on soils particularly over the grazing areas. However, much of the sampling was for specific targets or on a grid basis.

The chemistry of soils over the mine sites and tailings are less well defined. Some soil sampling and assessment of potential leachate production will be required to tie in with the stream water quality and to assess the risks and the engineering design requirements of cover or removal.

Many of the mining areas such as the area behind Silvermines village have been undisturbed for many years. Leaching will have reached some sort of equilibrium and disturbance is likely to remobilise the contamination. The issue will be whether the resultant level of contamination on and off the site will warrant removal to a contained site or limited movement, covering and collection of seepage to treat in wetlands or similar.

6.4 Stream Sediments

Stream sediment sampling has identified very high levels of metals and lead in particular. The source is either transport of solids from erosion of mine waste or precipitation of metals out of solution after leaching from the mine waste.

Contaminated sediments are widely distributed in all of the stream channels draining from the mining areas down to the Kilmastulla river and in the Kilmastulla River itself to just downstream of the GTMF.

6.5 Dust

Dust has been identified as a major issue from the GTMF and to a less extent from the Shallee tailings in the past. Although dust monitors have been set up on the GTMF, they are very close to the dam walls and therefore provide limited information on the extent of any modern dust blows. The vegetation, moss and algal cover on most of the tailings has prevented repeats of the serious blows of the early 1980's and monitoring has not revealed any significant dust emissions. The concern is whether deterioration of the vegetation cover on the GTMF will cause future problems to develop.

There are reported 'non visible' dust blows. This may be perceived due to the sulphurous smell that emanate from any sulphide rock waste but more extensive dust monitoring further away from the GTMF will be required to quantify this. The requirements for monitoring will be considered in Phase II.

The effects of dust blows are stream contamination, soil contamination, collection on herbage, health and safety from inhalation and nuisance.

There is sufficient data available to assess the remediation requirements but some further dust monitoring will be required to confirm the improvements. This monitoring does not form part of the present study.

6.6 Shafts, mine workings, cavities and surface subsidence

These aspects are fairly well known but not necessarily well defined. There is no detailed plan showing the extent or any description of the condition of the majority of the workings. Many sites must be considered as dangerous and there have been surprisingly few incidents involving humans or livestock as far as is known. There was one recorded fatality at Shallee due to someone falling down an opening. It is understood that this was in the 1930s.

A detailed survey should be carried out to locate all such openings and enable any further potential subsidence to be assessed. The main areas of subsidence between Shallee and Garryard could not be visited during the preliminary site visit due to FMD restrictions, but they will be visited during Phase II. Such inspection will have to be supported by orthophoto cover and topographic survey.

The minimum remediation would be to fence off the areas of concern using a low, unobtrusive fence around the areas of danger. This would not prevent access however and the risks would have to be clearly identified.

There are longer term potential issues with shafts especially those on the drainage adit through Silvermines village. Progressive erosion underground can weaken the shaft fill and cause collapse. This is a fairly common occurrence with old shafts that have not been closed with an engineered design. In most cases the easiest option is to fence them off. Some have been fenced but this needs to be improved. The adit itself is understood to be very narrow and in competent rock. It is therefore unlikely to be a cause of subsidence.

6.7 Surface structures

These have been described in section 5. Some of the structure are good and can be used for other purposes. Other buildings should be dismantled and removed as they are progressively deteriorating. Some materials such as asbestos roofing will require controlled disposal. The requirements will be specified in the conceptual design of Phase III.

6.8 Waste dump slope stability

There are two main types of dump. There are the large, prominent dumps around Magcobar comprised largely of low pyritic material and the smaller scattered low dumps of highly pyritic rock on all the other sites.

The issues for the large dumps are mainly visibility and stability. The latter is especially important where people have extracted rock from the toe of the dumps and over-steepened the slopes. There have been previous assessments of the stability of the Magcobar dumps, and these will be reassessed in relation to the new geometry. Some acid seeps can be observed around the Magcobar dumps but they are limited in extent and because the bulk of the waste is carbonate rock, the seeps are neutralised quickly and the metals immobilised.

Pyritic rock dumps are scattered over all the mine sites and the main hazard is leaching of metals and salts to contaminate surface and groundwater.

6.9 Tailings impoundment slope stability

Deep-seated instability of the Shallee tailings impoundment and other smaller impoundments is unlikely because of the well-drained nature of these deposits. The situation with the Gortmore TMF is different, because there is still a considerable amount of water within the impoundment. The risk of instability will be reviewed in Phase II.

6.10 Pathways, Receptors and Risks

Tables 6.1 to 6.5 summarise the key pathways and the key receptors. The most important receptors are people and animals and the most important impact is the potential exposure to high metals and lead in particular. In Phase II, the exposure risk will be developed further and this will govern the suitability of various remedial options. The most likely potential remedial measures will be identified in Phase II.

6.11 Preliminary Presentation of Remedial Options

During the work schedule of Phase II, options for final land use will be assessed. Preliminary options for the key isues are summarised in Tables 6.1 to 6.5 bu these will be revised in Phase II. The level of remedial action taken at each site will be dependent on the final land use which will in turn influence the costs. For instance, The GTMF dust blow issue can be stabilised using a thin soil cover and grass growth. However, this would not be suitable for grazing. If the final desired use for tailings is to be returned to grazing land then a thicker engineered cover will be required to prevent impacts to livestock and herbage.

The options for remedial measures will also consider the opportunities as well as the hazards. Some of the considerations will be:

- Development of the whole mine site area to provide a heritage walk to illustrate all the aspects of mining and mining history of the area with limited rehabilitation;
- Use of the rock dumps for aggregates and fill which can enable progressive rehabilitation and re-profiling while generating income. Some of the crushed rock could also provide protective and neutralisation cover for some of the waste materials on other sites;
- Development of individual sites for heritage purposes again with limited restoration of some areas;
- The GTMF could be developed as an ecological habitat with limited rehabilitation;
- The settlement pond at Garryard could be engineered to receive a large part of the contaminated drainage from the mine sites;
- The sediment pond at Garryard or part of the GTMF could be used to receive contaminated materials from the mine sites before closing with a formally engineered cover;
- The need to clear the drainage system of sediment from time to time. The sediment in many of the drains is contaminated and the sediment must be removed rather than placed on the fields adjacent to the drain.

Finally, there may be a "do-nothing" option for some sites depending on the level of risk and the wishes of the local community.

Table 6.1: Site : Ballygown

Source	Playing field*	Surface structures	Shafts	Underground mine		Waste rock dumps	Mine buildings/plant site
Hazard/issue	• Contaminated soil *(playing field is club field above school, not school playing field)	• Open pits • Stability • Wall rock oxidation	• Open shafts/adits • Collapse of backfill • Discharge of mine water	• Mine workings	• Sulfides/ oxidation products	• Sulfides/oxidation products • Erosion of contaminants	• Remnant stone structures at Calamine • Plant buildings at Knockanroe • Asbestos roof
Pathway	• Human ingestion/exposure • Erosion and seepage	• Leaching of metals from sulfides • Seepage to surface & groundwater ingestion by animals • Instability of excavations	• Access to shaft • Flooding or discharge to surface water	• Subsidence	• Seepage to groundwater/ surface water	• ARD/ metal leaching • Seepage to groundwater/ surface water	• Collapse and toxic dust
Receptors	• Human • Streams	• Surface water • Groundwater • Human & livestock safety	• Human & livestock safety	• Surface dwellings, • livestock, • human health	• Surface water • Groundwater	• Surface water (local stream in village) • Groundwater	• Human
Impact	• Toxicity • Stream quality	• Human & Livestock safety & health herbage toxicity • Unstable slopes	• Human & livestock safety	• Loss of land use, • Property damage, • livestock & human safety	• Human health • Livestock & herbage • toxicity	• Human health • Livestock & herbage • Toxicity • Unstable slopes	• Human & Livestock safety & health
Potential Remediation Options	• School field has now been covered with fill and site fenced • Village playing field requires cover of 150mm and improved drainage	• Stabilise slopes • Prevent access • Backfill • Re-profile surface • Improve diversion drainage • Intercept and treat seepage	• Prevent access • Cap shaft • Water pressure release	• Isolate high risk areas • Partial backfill	• Intercept and treat seepage • Removal of contaminated sediment from drainage adit • Construct wetland/install sediment control features • Install water treatment plant	• Intercept and treat seepage • Cover waste rock to minimise leaching • Reprofile • Remove from sensitive areas. • Remove and dispose contaminated material • Remove contaminated sediment from stream • Partial removal from stream/erosion control	• Potential heritage site • Dismantle • Possible use of some of plant buildings for farm purposes
Data	• Geochemistry	• Topography plan	• Detailed location/examination	• Locate on plan	• Sediment geochemistry & volumes • Water balance • Effluent quality	• Sediment geochemistry & volumes • Dump material geochemistry	
Work plan activities, Phase II	• Check remediation programme	• Sample and analysis ponded and seepage water • Field assessment of exposed rock reactivity • Identify unstable rock slopes and subsidence zones	• Identification of shafts • Field assessment of appropriate restoration option. • Sample and analyses discharge	• Desk study to determine high risk areas • Identify subsidence areas	• Identification of suitable disposal site • Compliance with licence requirements	• Sample and analyse seepage / streams in area of dump • Field assessment of reactivity • Identification of suitable disposal site • Compliance with licence requirements	• Assessment of mining heritage by industrial archaeologist • Ecological assessment

Table 6.2 : Site – Magcobar

Source	Open pit & adjacent limited underground workings*			Rock dumps			Mine buildings/plant site
Hazard/issue	• Slope stability • Subsidence of underground workings	• Deep water	• Contaminated water	• Visual	• Stability	• Sulphides/oxidation products	• Safety • Visual • After-use
Pathway	• Access	• Access	• Seepage to groundwater • Leaching from sidewalls • Ingestion by animals & birds • Water level rise	• Visible from a distance	• Slope failure	• ARD/ metal leaching • Seepage to groundwater/ surface water	• Visual • Access
Receptors	• Humans and livestock	• Livestock & human	• Surface water • Groundwater • Livestock & human	• Human	• Humans and livestock	• Surface water • Groundwater	• Humans and livestock
Impact	• Injury and death • Ravelling back outside present boundary	• Human & Livestock safety & health	• Contamination • Human & Livestock safety & health	• Visual	• Injury • Exposure of fresh material	• Contamination of water • Human health • Livestock toxicity	• Human s and livestock
Potential Remediation Options	• Prevent access by fencing (There is an existing, adequate fence) • Partial backfill • Remove waste rock pile from pit edge • Backfill (Landfill)	• Prevent access to pit by fence (existing) • Institutional controls	• Prevent access to pit by fence (existing) • In-situ treatment of lake water • Intercept and treat seepage/outflow • Water treatment plant	• Re-profile to blend with natural topography • Soften edges • Promote vegetation	• Prevent uncontrolled removal of stone from toe of slopes • Flatten slopes • Use as aggregate/fill source • Institutional controls	• Intercept and treat seepage • Cover waste rock to minimise leaching • Remove acid generating material	• Remove crusher plant • Remove oil tanks • Remove office • Consider after-use for core shed
Data	• Stability report available • Outcomes of landfill planning committee findings	• Legal requirements • Water balance • Water chemistry	• Legal requirements • Some depth sampling results available but more control data required • Water balance • Water chemistry	• Topographic survey • measure quantities • colonised vegetation species	• Legal requirements • Aggregate market	• Legal requirements • Sediment geochemistry & volumes • Disposal site selection • Water balance • Water chemistry • Borrow material sources	
Workplan activities, Phase II	• Review stability of pit • Assess subsidence		• Sample and analysis pit lake • Field assessment of wall rock reactivity • Assess potential for geological containment. • Assess risk of overtopping. • Groundwater investigation		• Topographic survey • Review stability, present geometry • Assess re-profile and quantities	• Sample and analyse seepage / streams in area of dump • Field assessment of reactivity	• Assess quantities and costs

* The underground workings are deep, limited in extent and only accessed from the floor of the pit. They do no constitute a hazard in themselves.

Table 6.3 Site : Garryard (Mogul)

Source	Settlement pond	Tailings Lagoon	Shaft	Underground mine		Waste dump (Triangle)	Mine buildings/plant site
Hazard/issue	• Contaminated water • Contaminated sediment	• Contaminated water	• Shaft collapse • Water discharge	• Subsidence	• Sulfides/oxidation products • Surface contamination	• Sulfides/oxidation products • Mill concentrate spillage	• Buildings • Contaminated land
Pathway	• Leaching of metals from sludge in pond • Seepage to surface & groundwater • Ingestion by animals	• Leaching of metals from sludge in pond • Seepage to surface & groundwater • Ingestion by animals	• Cap failure • Water head in workings	• Access	• Seepage to groundwater/ surface water	• ARD/ metal leaching • Seepage to groundwater/ surface water • Erosion to drains • Livestock access	• After-use or destruction of buildings • Leaching of chemicals from contaminated land
Receptors	• Surface water • Groundwater • Livestock water	• Surface water • Groundwater • Livestock water	• Human • Surface water	• Surface dwellings, livestock, human health	• Surface water • Groundwater	• Surface water • Groundwater	• Livestock, • Human health • Streams
Impact	• Contamination of local water supply • Human health • Livestock	• Contamination of local water supply • Human health • Livestock & herbage toxicity	• Human & livestock safety	• Loss of land use, • Property damage, livestock & human safety	• Contamination of local water supply • Human health • Livestock & herbage toxicity	• Contamination of local water supply • Human health • Livestock & herbage toxicity	• Human health & • Livestock safety, -toxicity of chemicals in local water supply
Potential Remediation Options	• Encourage wetland development for regional mine drainage treatment • Remove contaminated sediment • Reprocess sediment (ore) • Cover/encapsulate • Water treatment plant	• Engineered Cover • Intercept and treat seepage and ponded water • Divert clean water • Remove contaminated sediment • Reprocess sediment (ore) • Water treatment plant • Constructed wetland	• Monitor shaft area • Plug/backfill shaft	• Fence off high risk areas • Backfill with rock • Divert surface water	• Intercept and treat seepage • Divert surface water • In-situ bioreactor • Water treatment plant	• Intercept and treat seepage • Profile and engineer Cover • Remove waste to engineered containment	• Removal and site restoration • Utilise buildings • Profile and cover unsurfaced areas to prevent infiltration
Data	• Legal requirements • Flow and quality data required • Hydrological analysis • Disposal site selection • Sediment geochemistry	• Legal requirements • Flow and quality data required • Hydrological analysis • Disposal site selection • Sediment geochemistry • Reprocess site selection • Wetland site selection	• Legal requirements • Discharge flow especially after rain	• Legal requirements • Map subsidence	• Legal requirements • Shaft Discharge quality • Flow rates • Alternative discharge points	• Legal requirements • Downstream drain water quality • Water (seepage, surface runoff) chemistry • Borrow sources & geochemistry	• Legal requirements • Borrow sources & geochemistry • Disposal site selection • Sediment geochemistry
Workplan activities, Phase II	• Sample and analyse inflow and outflow	• Sample and analysis of ponded and seepage water • Field assessment of waste sludge reactivity • Bioavailability test on tailings	• Sample and analyse flow	• Map subsidence • Evaluate future potential based on desk evaluation of existing data and reports	• Sample and analyse discharge from shaft	• Sample and analyse seepage / streams in area of dump • Field assessment of reactivity	• Log unstable structures and contents • Assess quantities and costs

Table 6.4: Site: Shallee South/East

Source	Open pits		Shafts	Underground mine		Tailings		Waste dumps	Mine buildings/plant site
• **Hazard/issue**	• Pit lakes • Scrap and waste	• Safety	• Open shaft • Shaft collapse	• Subsidence/collapse	• Sulfides/oxidation products • Surface contamination	• Metals in dust	• Leaching of metals from tailings • Erosion of tailings	• Sulfides/oxidation products • Visual	• Buildings • Contaminated land
Pathway	• Seepage to surface & groundwater • Ingestion by animals • Access	• Access	• Access	• Access	• Seepage to groundwater/ surface water	• Aerial dispersion	• Erosion from embankments • Seepage to surface & groundwater	• ARD/ metal leaching • Seepage to groundwater/ surface water • Erosion to drains • Livestock access	• After-use or destruction of buildings • Leaching of chemicals from contaminated land
Receptors	• Human • Groundwater • Livestock	• Human • Livestock	• Human • Livestock	• Human • Livestock	• Surface water • Groundwater	• Local soil & herbage, • Livestock, • Farmhouses	• Surface water • Groundwater • Ingestion by animals • Precipitation in stream sediments	• Surface water • Groundwater • Visual • Health and safety	• Safety • Streams • Visual
Impact	• Human & Livestock safety • Visual	• Injury and death	• Injury and death	• Injury and death	• Contamination	• Toxicity in herbage • Dust nuisance • Loss of land use	• Contamination of surface water and groundwater	• Contamination of water	• Injury • Toxicity
Potential Remediation Options	• Drain • Fence off • Intercept and treat seepage and ponded water • Divert clean water • Remove scrap and waste	• Backfill or re-profile • Fence off	• Fence off • Engineered cap	• Fence off high risk areas • Collapse unsafe areas **Note:** **Potential development as a heritage site will require different approach**	• Intercept and treat seepage • Divert surface water	• Prevent surface disturbance by exclusion • Improve surface vegetation cover by addition of organic layer • Establish monitoring programme and contingency response	• Cover tailings to reduce leaching/erosion • Re-profile and cover • Intercept and treat seepage water • Construct sediment traps and vegetate • Maintenance and monitoring programme • Water treatment plant	• Intercept and treat seepage • Profile and engineer Cover • Remove waste to engineered containment	• Removal and site restoration • Utilise buildings • Re-profile waste and building areas and cover • On-site disposal • Collection of heritage items
Data	• Diversion Flow and pit water quality data required	• Extent of open areas and subsidence	• Position and condition of all shafts		• Underground flows and quality	• Limited soil and water data available	• Limited soil and water data available	• Downstream drain water quality	
Work Plan activities, Phase II	• Sample and analyse ponded and seepage water	• Detailed site survey	• Map shafts and condition	• Review heritage plans and other options • Assess stability	• Sample and analyse • Develop conceptual groundwater model	• Obtain soil chemistry • Assess natural vegetation colonisation	• Sample and analyse seepage water • Quantify contaminant flows to surface and ground water • Field assessment of tailings reactivity • Bioavailability test on tailings • Evaluate sources of remediation materials	• Sample and analyse seepage / streams in area of dump • Field assessment of reactivity	• Log unstable structures and contents • Assess demolition • Assessment of mining heritage by industrial archaeologist

Note: Shallee West could not be accessed during the initial field visit.

Table 6.5 : Site : Gortmore TMF

Source	Tailings		The tailings pool	The three return water ponds	Delivery pipe line
Hazard/issue	• Metals in dust	• Leaching of metals from tailings • Erosion of tailings • Deep-seated slope instability	• Contaminated water	• Contaminated water	• Remaining pipe with residue • Sediment from pipe breaks
Pathway	• Aerial dispersion	• Erosion from embankments • Seepage to surface & groundwater • Slope failure and possible flow	• Seepage to groundwater • Flow to return water ponds along discharge channel	• Seepage to groundwater • Flow to river	• Access
Receptors	• Local soil & herbage, • Kilmastulla river, • Livestock, • Farmhouses	• Surface water • Groundwater • Ingestion by animals • Precipitation in stream sediments • Mass flow into river	• Kilmastulla River • Groundwater	• Kilmastulla river • Groundwater	• Local soil & herbage, • Humans, Livestock
Impact	• Poor vegetation growth, • Elevated metals in soils, • Animal & human toxicity • Metals in stream sediment • Nuisance (dust)	• Contamination of Kilmastulla river • Human health • Livestock & herbage toxicity • Sediment from drain clearance spread on fields	• Contamination of Kilmastulla River • Human health • Livestock, bird and herbage toxicity	• Contamination of Kilmastulla river • Human health • Livestock, bird & herbage toxicity	• Human health, • Livestock & herbage toxicity
Potential Remediation Options	• Prevent surface disturbance by exclusion for general access and grazing • Improve surface vegetation cover by addition of organic layer • Establish monitoring programme and contingency response • Vegetation wind breaks	• Cover tailings to reduce leaching • Re-profile and cover • Construct sediment traps and vegetate (non-forage spp.) • Drain sediment removed to TMF • Maintenance and monitoring programme • Water treatment plant • Institutional controls	• Intercept and treat seepage and ponded water • Drain pool and vegetate • Constructed pond decant system	• Intercept and treat seepage • Cover over pond area to restore site • Improve wetland system and establish maintenance and monitoring programme • Armour embankment crest • Institutional controls	• Removal of pipe and site restoration (note: it is understood that the pipe has been removed-requires check) • Remove break out residues
Data	• Soils analysis from the three deposition areas • wind direction data • dust monitoring	• More detailed sampling required • Stability analyses	• Some water quality available • Tailings geochemistry • Pool and discharge channel water quality	• Detailed plan of wetland system • Water quality of pond units required • Some inflow and outflow data available	• Map pipeline route for residues • Records of breaks
Work plan activities, Phase II	• obtain soil chemistry data from Sligo, • review available wind and monitoring data • review vegetation study reports	• Review stability of present geometry after recent earthworks • Field assessment of tailings reactivity • Bio-availability test on tailings • Evaluate sources of remediation materials	• Sample and analyse lagoon and seepage water Quantify contaminant flows to surface and ground water •	• Sample and analyse ponds	• Check tailings discharges on pipeline route.

7 PERFORMANCE CRITERIA FOR REMEDIAL OPTIONS

7.1 Standards

Performance criteria will be defined during the Phase II study covering the physical, chemical and biological standards as well as social and public health issues. The subject is introduced in this Phase I report.

Standards and regulations will provide the framework in which remedial options are selected. However, the best options will be an integration of a number of aspects, based on a risk-based approach and including:

- Public health and safety;
- Land use options which may be influenced by existing land use, the wishes of local people as well as technical and practical feasibility;
- Interpretation or adaptation of standards such as the selection of points of compliance for water quality standards;
- Land ownership;
- Costs, the flow of funds, project sequencing and prioritisation;
- An assessment of the risk of failure and consequences for any option selected.

7.2 International guidelines and practice

In terms of the requirements for the project, the majority of guidelines for closure have been developed in the USA although others are being developed in Europe. The most quoted reference is the Ontario guidelines (Rehabilitation of Mines – Guidelines for Proponents, Ontario Ministry of Northern development and Mines, 1995). The Queensland (Australia) and United States Bureau of Mines (USBM) standards also provide useful guidance.

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Direct input to the project related to the guidelines and current practice in the USA will be provided through Jeff Parshley of SRK North America during Phase II.

7.2.1 Irish Standards

The EPA was established in 1992 and has guidelines for a number of aspects of mining activities that potentially impact on the environment. These guidelines are for existing or proposed operations.

Discussions with the Irish EPA indicate that there are currently no Irish groundwater standards, however the EPA are currently working on producing a set of standards for groundwater.

In the interim in areas prior to any anthropogenic influences, the EPA advise that reference is made to drinking water standards i.e. SI No. 81 of 1988, which will be revoked by SI No 439 of 2000 but not until 1st January 2004. For example standards in drinking water for Pb are 0.05 mg/l, Zn 1 mg/l, Cd 0.005 mg/l and Fe 0.2 mg/l. However the implications of the background levels of metals (*in situ* mineralogy) and the effects of mining need to be considered.

The ideal for abandoned mines would be to achieve the guideline targets and methods as far as possible, but the actual discharges are governed by regulation in various parts of the legislation. In the EPA guidelines, reference is given to European Union regulations in Irish law that will be used as the target for compliance and modified where prudent and acceptable.

For the purposes of the Phase II reporting specific reference has been made to the following:

- The Dutch Ministry of Housing, Spatial Planning and Environment (2000) *Circular on Target Values and Intervention Values for Soil Remediation*
- US EPA (1996) *Soil Screening Guidance: User's Guide* and *Fact Sheet*
- Scotland and Northern Ireland Forum for Environmental Research (2000) *Framework for Deriving Numeric Targets to Minimise the Adverse Human Health Effects of Long-term Exposure to Contaminants in Soil*.

In addition to the above guidelines and standards, the *Environmental Contaminants Encyclopedia* produced by the US National Parks Service (1997) has also been referenced for particular contaminants in the absence of precedent standards or as a means of verifying existing guides.

7.3 Public acceptance

Public acceptance is very important and can be perceived to be a more critical criterion than the need for health and safety or the legislated standards, especially where there is a desire to retain a mining heritage.

The proposed workshop meeting to take place towards the end of the project will enable the public to express their acceptance or otherwise of various issues. Some aspects of public attitudes have already been clearly identified from the discussions so far and public opinion will continue to form part of the ongoing evaluations.

It is important to recognise that individuals and groups will have different perspectives on what is acceptable or not depending on their own desires and requirements. These may often be in conflict with other groups or individuals. Therefore it may not be possible to satisfy all demands.

7.3.1 Health and Safety

A key issue in terms of health and safety is lead in water supplies or lead that is potentially taken up by direct contact or ingestion. This has been extensively addressed in the IAG report. Other issues include heavy metals and the safety of shafts and workings. Performance criteria will be based on compliance with prescribed standards/limits and on reduction of exposure to acceptable levels, and the advice of the expert group will be sought.

7.3.2 Land use

Existing land use is principally residential and farming, with some commercial activity.

Studies to date have shown that away from the mining sites themselves, areas of contamination are not extensive. There are some areas of particular importance, however. Land contaminated by mining activity has been purchased by private owners and the risk and remediation issues need to be clearly understood and where required, reviewed against applicable standards. These areas include the Gortmore TMF, the Mogul plant site, the Mogul lagoon and settlement ponds and the Mogul old stockpile south of the plant site. The plant site is currently used by a transport company but has greater potential provided rehabilitation work is undertaken and appropriate safeguards put in place.

The other sites described above will require extensive rehabilitation work based on the estimated risk to the environment. Subject to nomination of post-closure land use work may make them suitable for some alternative commercial use but they are not suitable in their present condition.

The ownership of mining sites south of the Shallee road, comprising the actual mined areas and the waste dumps is not clear at present. However, many of the sites are grazed by cattle and sheep.

7.3.3 Aesthetics

To date, the aesthetic aspects have not been raised as a key public concern except by one or two people. The concerns raised have also been raised as a result of other concerns and not the aesthetic aspects alone.

The main visual intrusion centres on the waste rock dumps at Magcobar but this intrusion can be improved without extensive work. This aspect will be further evaluated during Phase II.

7.4 Technical Limits

On abandoned mine sites there is usually a compromise between the technical possibilities, the standards and the costs. In the Silvermines area, the natural soils and water contain levels of metals, which exceed standards.

7.4.1 Water discharges

The performance requirements for remediation of mine water discharges are sometimes difficult to define. Difficulties that often arise are:

- Discharge performance relative to ambient conditions, which may in fact not comply with prescribed standards;
- Adoption of a compliance point as to whether it should be the discharge itself or at some point in the receiving water course;
- The standard which should be achieved, and;
- Whether any improvement is acceptable whether it achieves a standard or not.

Table 7.1 gives water discharge standards.

Table 7.1: Emission Limit Values for Discharges to Water

Parameter	Limit Value
PH	6-9
BOD	90% removal or 25mg/l
Toxic units	5TU
Total Nitrogen (mg/l as N)	>80% removal or 15 mg/l
Total Phosphorus (mg/l as P)	>80% removal or 2 mg/l
Total Ammonia (mg/l as N)	5
Oils, fats and grease (mg/l)	25
Fish Tainting	No tainting
Mineral (Oil (interceptor) (mg/l)	100
Mineral Oil (effluent mg/l	1
Metals, Cyanides etc	As appropriate

The table is extracted from "Integrated Pollution Control Licensing, BATNEEC guidance note for the extraction of minerals, EPA, 1997".

It should be noted that all values refer to daily averages except where otherwise stated and except for pH which refers to continuous values. Limits apply to effluent prior to dilution with uncontaminated streams. The determination of limits for metals and cyanides at the time of licensing are based on consideration of appropriate technologies and the requirement of the receiving environment. In this regard particular attention should be paid to the maximum acceptable concentration standards (wherever relevant and applicable) for the chemical parameters of:

(a) S.I.No.293 of 1988 – European Communities
(Quality of Salmonid Waters)Regulations 1988.

(b) S.I.No.294 of 1989 – European Communities
(Quality of surface Water intended for Abstraction of Drinking Water intended for Human Consumption) Regulations 1989.

(c) S.I.No.200 of 1994 – European Communities
(Quality of Shellfish Waters)Regulations 1994

The Irish water quality standards are based on the European Standards and are summarised in Table 7.2.

7.4.2 Dust

The concern in the past has been dust blow from the tailings facilities. The present concern is the threat of future dust blows due to progressive deterioration of the vegetation cover on the GTMF. Although dust monitoring and contingency planning will continue, the measure of compliance will be the development and maintenance of a sustainable cover over the whole of the GTMF.

7.4.3 Soils

The measurement of success for remediating soils will be based on:

- The engineering aspect of controlling the source of contamination, and;
- Reduction in the exposure of people and animals to lead in particular.

Table 7.2 : Irish water quality standards

Regulation Statutory Instrument No	Unit of Analysis	Drinking Water S.I. no 81 of 1988 I/MAC value	A1 I/MAC value	Surface Water S.I. No 294 of 1988 A2 I/MAC value	A3 I/MAC value	Salamonid Water Regulations S.I. No 293 of 1988 I/MAC value
Aluminium	Al mg/l	0.2				
Ionised ammonia	NH4 mg/l	0.3	0.2	1.5	4	<1, subject to conforming with the standard for non-ionised ammonia
Un-ionised ammonia	NH3 mg/l					≤0.02 (Standard may be exceeded in the form of minor peaks in daytime).
Antimony	Sb μg/l	10				
Arsenic	As μg/l	50	50	50	100	
Barium	Ba μg/l	500	100	1000	1000	
Berylium	Be mg/l					
Boron	Bμg/l	2000	2000	2000	2000	
Cadmium	Cd μg/l	5	5	5	5	
Calcium	Ca mg/l	200				
Chloride	Cl/mg/l	250	250	250	250	
Chlorine residual	Cl mg/l					≤0.003 in 95% of samples over 12 months on sampling at least once per month
Chromium	Cr mg/l	50	50	50	50	
Cobalt	Co mg/l					
Conductivity	μS/cm @ 20°C	1500	1000	1000	1000	
Copper	Cu μg/l	500	50	100	1000	≤5@10mg/l$CaCO_3$, ≤22@50mg/l$CaCO_3$, ≤40@100mg/l$CaCO_3$, ≤112@300mg/l$CaCO_3$
Cyanide	CN μg/l	50	50	50	50	
Fluoride	F μg/l	1000	1000	1700	1700	
Hydrogen ion concentration	pH	6.0-9.0	5.5-8.5	5.9-9.0	5.5-9.0	≤6 and ≥9 in 95% of samples over 12 months, sampling at least once per month
Hydrocarbons dissolved and emulsified	μg/l	10	10	200	1000	Petroleum products must not form a visible film on surface or impart a detectable hydrocarbon taste to fish
Iron	Fe μg/l	200	200	2000	2000	
Lead	Pb μg/l	50	50	50	50	
Magnesium	Mg mg/l	50				

TABLE 7.2 : Irish water quality standards (cont'd)						
Manganese	Mn μg/l	50	50	300	1000	
Mercury	Hg μg/l	1	1	1	1	
Methylene blue – active substances	LAS μg/l	200	200	200	200	
Molybdenum	Mo mg/l					US NAS recommendation for irrigation water is 0.01mg/l
Nickel	Ni μg/l	50				
Nitrate	NO_3 mg/l	50	50	50	50	
Nitrate	NO_2 mg/l	0.1				≤0.05 in 95% of samples over 12 months, sampling at least once per month
Oxygen demand, biochemical	O_2 mg/l		5	5	7	
Oxygen, dissolved	O_2 mg/l % sat		>60%	>50%	>30%	1:50% ≥9 mg/l O_2
Pesticides	μg/l	0.5 (TOT):0.1(IND)	0.5	2.5	5.0	
Phenols	O_6H_5OH μg/l	0.5	0.5	5	100	Phenolic compounds must not be present in such quantities that they adversely affect fish flavour
Phosphates	P_2O_5 μg/l	5000	500	700	700	
Polynuclear Aromatic Hydrocarbons	μg/l	0.2	0.2	0.2	1.1	
Potassium	K mg/	12				
Selenium	Se mg/l	0.01	0.01	0.01	0.01	
Silver	Ag μg/l	10				
Sodium	Na mg/l	150				
Sulphate	SO_4 mg/l	250	200	200	200	
Tellurium	Te mg/l					
Thallium	TI mg/;					
Titanium	SN mg/l					
Tin	Ti mg/l					
Uranium	U mg/l					
Vanadium	V mg/l					
Zinc	ZN mg/l					≤0.03@10mg/l $CaCo_3$, ≤0.2@50mg/$CaCo_3$, ≤0.3@100mg/l$CaCo_3$, ≤0.5@500mg/l$CaCo_3$

TOT – Total; IND = Individual; % SAT = Percentage Saturation; LAS = Lauryl Sulphate; I/MAC – Mandatory maximum admissible concentration

8 THE PHASE II STUDY

8.1 Introduction

The main purpose of the Phase I study of available information was to determine the required extent of the Phase II fieldwork, sampling and testing. The original proposal was based on assumptions about the sufficiency of the available information and, during the Phase I study, the validity of these assumptions has been assessed.

The overall objective of Phase II is to develop remedial options and to select a preferred option. Any additional data requirements are only to confirm preliminary thoughts and ideas or to fill gaps. Some of the additional data can be collected in the future but some will be required to confirm conceptual models such as for groundwater.

In general, there has proved to be a large amount of existing laboratory information from the testing of soils and water, but there are certain gaps to be filled and check tests to be carried out. The criterion used by SRK in determining the extent of the proposed additional sampling and testing has been – Is there sufficient information to select the correct remedial solution?

8.2 The Phase II programme

The prime objective of the Phase II programme is to develop preferred options for remediation. In general, the Phase I study has provided a large volume of useful information, but has revealed nothing requiring major additions to the Phase II programme. Thus, the Phase II field study will not vary significantly from that described in the original proposal. In the sections below, the minor changes to the Phase II study which are considered appropriate are explained, and more information is provided about the methodology.

8.3 Site sampling and testing of water and soils

The purpose of the Phase II site investigation will be to

- further inspect the study area, including parts not yet visited;
- to take samples of water and soil for field and laboratory testing;
- to further consult with the local authority and others;
- gather any additional documentary information.

In addition to these issues, it was mentioned in the SRK proposal that samples of vegetation would also be collected for analyses. This is not considered necessary for Phase II, as the information gathered as part of Phase I indicates extensive herbage, hay and silage data already exists and that other institutions are undertaking detailed on-going analysis (e.g. Teagasc). However, SRK will remain aware of this aspect, and will liaise with such institutions. This liaison will ensure the incorporation of any relevant findings into the assessment of the options for final land rehabilitation.

According to the data that has been reviewed and summarised, the main sources of soil and surface water contamination are the old tailings facilities, lagoons and stockpiles. The existing data does not, however, indicate the exact source of the contamination. This is because the sampling was downstream of the contaminant sources, where dilution will have occurred. With this information site rehabilitation options cannot be fully evaluated, as the contaminant sources are not completely understood. For these reasons, SRK recommends supplementing the existing data with more detailed sampling, aimed at better assessing the exact source of contaminant sources. The areas where information is insufficient are around the waste dumps which drain into the Yellow River on the north side of the Silvermines Mountains and south of Silvermines village in the Ballygown. Data gaps also exist for the Magcobar, Shallee, Garryard and Gortmore areas.

In all areas, information regarding groundwater quality and flow is lacking. SRK understands, however, that screened boreholes do exist at Magcobar, and it is anticipated that these will be accessible during Phase II. These holes were drilled specifically for the investigation into the proposed refuse disposal at Magcobar, and the condition of the boreholes is unknown. Additional drilling to supplement the understanding of the groundwater system and groundwater contamination will be recommended in Phase II. Conceptual models for the groundwater system can still be developed and conceptual remedial design options developed. Remedial options would be modified as necessary with the additional information.

It is proposed that a combination of field and laboratory test-work of soil, surface water and, where accessible, groundwater, be undertaken to provide the required additional information. Sampling of surface and groundwater will include the measurement of the field pH, temperature, electrical conductivity (EC), redox potential (Eh), dissolved oxygen (DO), alkalinity and acidity. Where considered applicable, this data will be supplemented by analysis of field metals (Fe and Mn) and sulfate, using a portable spectrophotometer. At surface water sites an estimate of flow rate will also be made. At strategic locations, samples of surface water will be collected for laboratory analysis. These samples will only be collected in areas where previous data does not exist. For instance, in the area between Shallee and Magcobar, samples would be collected from individual waste dump drainage channels. This will then allow comparison of drainage quality, which will result in a better understanding of the pollutant sources and will permit a risk-based assessment of rehabilitation options to be made. The exact number of samples to be collected cannot be precisely predicted, as this will need to be confirmed on site. However, realistic nominal figures, based on the extent of data gaps and the Phase I site assessment have been used for costing purposes.

The sampling protocols and analytical methodologies used in previous studies of the area are not readily available or reported. As a result, the integrity of the data can not be fully assessed. In order to ensure that this does not occur in the present study, a summary of the Phase II field sampling protocols are given in Appendix D. These appendices will be updated in the Phase II report to include the laboratory techniques used and any other supporting QA/QC data. As the water samples will be taken from areas not previously characterised, it is prudent that they be analysed for a full suite of determinants.

In conjunction with the sampling of surface and groundwater, sampling of soil, tailings material and waste material is recommended. Again, this will include a combination of field and laboratory analysis aimed at assessing the potential reactivity of material, total contaminant content and leachability. The field sampling will include measurement of paste pH and paste Electrical Conductivity (EC). The measurement of paste pH and EC is aimed at determining the pH and EC of pore water resulting from the dissolution of secondary mineral phases on the surfaces of oxidised rock particles. The results will indicate whether oxidation, and accumulation of contaminants in the form of secondary mineral phases has occurred in the waste material prior to collection of the sample. Laboratory analysis will include an assessment of total metals content in soil and also a four-stage extraction aimed at assessing which mineral fractions contain the greatest amount of contaminants and how leachable these metals are. It is anticipated that this information will help assess why certain areas are not vegetated and the source of potential contaminants.

SRK anticipates that the results gained from the Phase II testwork will be combined and assessed with the results gained by other parties, so as not to duplicate resources and also to ensure that rehabilitation options are based on the most current and relevant data. SRK envisages this task as key to successful cost-effective rehabilitation and co-operation between the various research parties will be encouraged.

8.4 Complete photographic record & inventory of surface structures

The photography and the collection of the information required for the photographic record and inventory have been almost completed during Phase I. In Phase II the information will be compiled and checked.

It is probable that underground inspections of the Mogul and other workings will not be possible, but that the assessment of underground conditions will be based on the available records. Parts of the Shallee workings are accessible, but these have already been partially inspected by SRK for a previous geotechnical assessment related to the development of the proposed Shallee Mining Heritage Centre.

8.5 Assessment of site environment and pollution

8.5.1 Heritage

The historic assessment will be carried out by an industrial archaeologist, in consultation with Mr. De Staffort of Silvermines of Shannon Development, who has offered assistance and has considerable local knowledge.

8.5.2 Mine safety

Reports on the stability of the underground workings and on the existing subsidence have been obtained, and plans of the workings have been gathered. An SRK geotechnical engineer will review the long-term stability of the workings, as far as is possible with the available information. This will not be a detailed analysis, but will allow a qualitative prediction of the risk for the various areas.

The status of shafts and adits will be assessed from the records and by inspection, as far as this is possible. Some shafts appear to have been properly sealed, but most have not. Many of these unsealed shafts have become covered by soil or obscured by thick vegetation, and it may not be possible to identify their positions or condition. A tabulation will be prepared.

If it is considered necessary, further work will be recommended, using a risk-based approach.

8.5.3 Subsidence areas

The areas of existing subsidence to the west of Magcobar and elsewhere will be inspected and assessed in conjunction with the geotechnical prediction of future subsidence. This assessment will influence the management plan for the area, the provisions for public access and the recommendations for monitoring.

8.5.4 Slope stability

Reports on stability assessments of the Gortmore TMF and the Magcobar waste dumps have been obtained, and the deposits have been inspected. The risk of future instability will be assessed using this information, and the effects of changes in slope geometry and water conditions on stability will be considered. For example, the recent excavations at the Magcobar dump have changed the slope geometry, and there have been slope alterations at the Gortmore TMF.

8.5.5 Surface water hydrology

The detailed sub-catchment plan has not been prepared during Phase I, but will be produced in the early stages of Phase II. Rainfall data has been obtained, and will be used to predict seasonal flows for use in pollution predictions and in the conceptual design.

8.5.6 Groundwater hydrology

Groundwater will be sampled where possible from adits, shafts and boreholes, and the need for additional drilling will be considered during Phase II.

8.5.7 Flora and fauna

The ecological assessment has been partly completed during the Phase I study, and Phase II will be concerned mainly with areas which were inaccessible during Phase I.

8.5.8 Assessment of existing and potential impacts

There is no change to the procedure proposed for the assessment of impacts.

8.5.9 Risk assessment

In the Phase I report, the identified hazards have been presented. In the Phase II study, possible additional hazards will be identified, and the risks will be assessed in more detail, in order to judge the efficacy of the alternative remedial options.

8.6 Review of rehabilitation options & recommendations for preferred option

It is anticipated that the options will be presented to DMNR during the final part of the Phase II study, and that the preferred options will be selected using the matrix of information in the table 6.1 to 6.5 in consultation with DMNR.

8.7 Costs for Phase II

The costs for Phase II will be in accordance with the original proposal, except that it is proposed that some additional laboratory testing is required, and there is also a need for additional drilling. The drilling will provide information on the levels and extent of contamination of groundwater. The information will be required to complete the understanding of the groundwater system and what the implications may be for future management of groundwater/surface water. This information is not critical for the conceptual design of surface remediation and will be discussed with DMNR before the end of Phase II.

The following presentation is concerned entirely with the cost of laboratory testing. For the planning of the fieldwork for Phase II, the site has been split into six areas. These areas are:

- Waste dumps on the northern slopes of the Silvermines Mountains;
- Shallee South/East and Shallee West;
- Ballygown area south of the Silvermines village;
- Magcobar;
- GTMF; and
- Garryard mining complex.

For each area, the proposed sampling location and the number and type of field and laboratory analyses to be made are summarised in individual tables (Tables 8.1 – 8.6). Costs for making field readings have not been included, as these will be covered by the professional fees for the site work.

The laboratory costs are approximate. They may be reduced, depending on the final number collected and analysed. Also, the EPA has offered to undertake a small quantity of water analyses at a reduced cost, which would reduce the final cost. This possibility is under discussion, and will be finalised before the sampling is initiated.

A summary of the estimated total laboratory cost is made in Table 8.1.

Table 8.1 Summary of analytical costs for Phase II

Site	Estimated laboratory costs (£)
Shallee East and West	**820**
Waste dumps on northern slopes of Silvermines Mountains	**640**
Magcobar	**560**
Gortmore TMF	**1045**
Calamine Area south of Silvermines village	**770**
Garryard complex	**895**
TOTAL COST (£)	**4730**

An amount of £2500 was allowed in the original proposal, and the present estimate includes an additional £2230. It is recommended that the additional budget should be £3000, to include a contingency amount.

Table 8.2 : Phase II sampling recommended at Shallee

Shallee East and West							
Location	**Field Readings**			**Laboratory Analysis**			
	Paste pH and EC	pH, EC, T, Eh, Alkalinity, Acidity, DO, Fe, SO_4.	Stream Flow Estimate	**Soil:** Total metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Mn and Fe)	**Soil:** Extractable metals – each extractant analysed for As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Mn and Fe	**Water** *:Major and trace constituents**	**TOTAL COST**
Cost per analysis (£)	**-**	**-**	**-**	**15**	**100**	**80**	
4 × Surface Soil	4			4	1		**160**
4 × Sub surface soil	4			4	1		**160**
2 × Upstream of tailings		2	2			1	**80**
2 × Downstream of tailings		1	1			1	**80**
1×composite ponded water		1				1	**80**
6 ×Surface waste	6			6			**90**
6 × Subsurface waste	6			6			**90**
2 × Unnamed drainage channels		2	2				**–**
3 × Open cut Sump – Surface water		3				1	**80**
Total estimated cost of analysis (£)							**820**

* - EPA has offered to undertake some analyses at reduced cost to project – to be confirmed.

** - Major elements – Na, K, Mg, Ca, SO_4, Cl, F, NO_3, NH_3, PO_4

Trace elements - Filtered and total Al, Fe, Mn, Ni, Cu, Zn, Cr, V, Hg, As, Ba, Sn, Pb, Cd, total CN

Table 8.3 : Phase II Sampling Recommended at Gorteenadiha

Waste dumps on northern slopes of Silvermines Mountains					
Location	**Field Readings**			**Laboratory**	
	Paste pH and EC	pH, EC, T, Eh, Alkalinity, Acidity, DO, Fe and SO_4.	Stream Flow Estimate	**Water** *: Major and trace constituents**	**TOTAL COST**
Cost per analysis (£)	**-**	**-**	**-**	**80**	
10 × Surface dump material	10				
10 × Un-named drainage channels – upstream of dumps		10	10	4	**320**
10 × Un-named drainage channels – downstream of dumps		10	10	4	**320**
			Total estimated cost of analysis (£)	**640**	

* - EPA has offered to undertake some analyses at reduced cost to project – to be confirmed.

** - Major elements – Na, K, Mg, Ca, SO_4, Cl, F, NO_3, NH_3, PO_4

Trace elements - Filtered and total Al, Fe, Mn, Ni, Cu, Zn, Cr, V, Hg, As, Ba, Sn, Pb, Cd, total C

Table 8.4 : Phase II sampling recommended at Magcobar

Magcobar					
Location	**Field Readings**			**Laboratory Analysis**	
	Paste pH and EC	pH, EC, T, Eh, Alkalinity, Acidity, DO, Fe, SO_4.	Stream Flow Estimate	**Water** *: Major and trace constituents**	**TOTAL COST**
Cost per analysis (£)	**-**	**-**	**-**	**80**	
10 × Waste dump material in areas of drainage	10				
5 × Un-named drainage channels – upstream of dumps		5		1	**80**
5 × Un-named drainage channels – downstream of dumps		5		1	**80**
2 × Pit lake – Surface water		2		1	**80**
2 × Pit lake Sump – Deeper water		2		1	**80**
3 × Accessible groundwater wells		3		3	**240**
Total estimated cost of analysis (£)					**560**

* - EPA has offered to undertake some analyses at reduced cost to project – to be confirmed.

** - Major elements – Na, K, Mg, Ca, SO_4, Cl, F, NO_3, NH_3, PO_4

Trace elements - Filtered and total Al, Fe, Mn, Ni, Cu, Zn, Cr, V, Hg, As, Ba, Sn, Pb, Cd, total CN

Table 8.5 : Phase II sampling recommended at GTMF

Gortmore TMF							
	Field Readings			**Laboratory Analysis**			
Location	Paste pH and EC	pH, EC, T, Eh, Alkalinity, Acidity, DO, Fe, SO_4.	Stream Flow Estimate	**Soil:** Total metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Mn and Fe)	**Soil:** Extractable metals – each extractant analysed for As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Mn and Fe	**Water** *: Major and trace constituents**	**TOTAL COST**
Cost per analysis (£)	**-**	**-**	**-**	**15**	**100**	**80**	
50 × Surface Soil	50			6	1		**190**
10 × Sub surface soil				6	1		**190**
1 × Stream sediment				1	1		**115**
3 × Drainage channels upstream of tailings		3	3	1	1	2	**275**
3 × Drainage channels downstream of tailings		3	3	1	1	2	**275**
2 × Ponded water		2					
Total estimated cost of analysis (£)							**1045**

* - EPA has offered to undertake some analyses at reduced cost to project – to be confirmed.

** - Major elements – Na, K, Mg, Ca, SO_4, Cl, F, NO_3, NH_3, PO_4
Trace elements - Filtered and total Al, Fe, Mn, Ni, Cu, Zn, Cr, V, Hg, As, Ba, Sn, Pb, Cd, total CN

Table 8.6: Phase II sampling recommended in Ballygown area

Calamine Area south of Silvermines village							
Location	**Field Readings**			**Laboratory**			
	Paste pH and EC	pH, EC, T, Eh, Alkalinity, Acidity, DO, Fe, SO_4.	Stream Flow Estimate	**Soil:** Total metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Mn and Fe)	**Soil:** Extractable metals – each extractant analysed for As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Mn and Fe	**Water** *: Major and trace constituents**	**TOTAL COST**
Cost per analysis (£)	**-**	**-**	**-**	**15**	**100**	**80**	
20 × Surface soil	20			4	2		**260**
40 × Waste Dump material	40			6	1		**190**
5 × Un-named drainage channels		5	5			2	**160**
3 × Un-named drainage channels – downstream of dumps		3	3			1	**80**
1 × Discharge from drainage adit		1	1			1	**80**
3 × Ponded water							
Total estimated cost of analysis (£)							**770**

* - EPA has offered to undertake some analyses at reduced cost to project – to be confirmed.

** - Major elements – Na, K, Mg, Ca, SO_4, Cl, F, NO_3, NH_3, PO_4

Trace elements - Filtered and total Al, Fe, Mn, Ni, Cu, Zn, Cr, V, Hg, As, Ba, Sn, Pb, Cd, total CN

Table 8.7 : Phase II sampling recommended at Garryard

Garryard complex							
Location	**Field Readings**			**Laboratory**			
	Paste pH and EC	pH, EC, T, Eh, Alkalinity, Acidity, DO, Fe, SO_4.	Stream Flow Estimate	**Soil:** Total metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Mn and Fe)	**Soil:** Extractable metals – each extractant analysed for As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Mn and Fe	**Water** *: Major and trace constituents**	**TOTAL COST**
Cost per analysis (£)	**-**	**-**	**-**	**15**	**100**	**80**	
10 × Surface soil	10			6	1		**190**
3 × Triangle waste dump material				3	1		**145**
5 × Un-named drainage channels – upstream of site		5	5			2	**160**
5 × Un-named drainage channels – downstream of site		5	5			2	**160**
1 × Discharge from shaft		1	1			1	**80**
2 × Ponded water in settlement pond		2				1	**80**
2 × Ponded water in lagoon		2				1	**80**
Total estimated cost of analysis (£)							**895**

* - EPA has offered to undertake some analyses at reduced cost to project – to be confirmed.

** - Major elements – Na, K, Mg, Ca, SO_4, Cl, F, NO_3, NH_3, PO_4

Trace elements - Filtered and total Al, Fe, Mn, Ni, Cu, Zn, Cr, V, Hg, As, Ba, Sn, Pb, Cd, total CN

9 CONCLUSIONS

The Phase I study of available information has served its main purpose of confirming the nature and extent of the available information and what is required for sampling and testing in Phase II. The assessment of the available information is still in progress.

The site inspection which formed a necessary part of Phase 1 was disrupted by the restrictions imposed by the foot and mouth controls, but this did not prevent the completion of Phase I, apart from the proposed Workshop for Interested and Affected Parties. Smaller meetings were substituted without site visits by the participants and were successful. A full workshop will be held towards the end of the project, when the restrictions are lifted.

From the review of available information and from discussion with mining companies, Agencies, Universities and local people, the nature of the Phase II study included in the original proposal was confirmed. There has been one significant change. Certain gaps were discovered in the water and soil testing data that could have a potential influence on the selected remedial works. For this reason, an additional testing programme, at an additional cost of approximately £3000 in laboratory costs, has been proposed.

Very little information has been obtained about the groundwater regime and additional information is required to confirm conceptual models of the groundwater system and establish the water quality. Some drilling and testing will be required and will be reviewed during Phase II, and discussed with the DMNR. SRK's present feeling is that, although such work will be required for confirmation, it may only be required after the completion of the conceptual design and prior to the detailed design and implementation.

Preliminary assessments of the hazards, pathways, receptors and the data requirements have been done and summarised in tables 6.1 to 6.5. These will form the basis of the investigation for Phase II in which the tables will be expanded and used to assist in selecting suitable remedial options.

10 REFERENCES AND BIBILIOGRAPHY

The references and bibliography are tabulated in Appendix A. There are some additional, important sources of data which have been identified but not yet received or which have not yet been reviewed. These include the results of work carried out by staff of the Sligo Institute of Technology. The outstanding information will be obtained during the Phase II study.

11 ACKNOWLEDGEMENTS

During the information gathering phase, SRK has contacted numerous individuals and organisations, including mining companies, Government Departments, Local Authorities, Universities, trade associations, farmers and local residents. Without exception, the people contacted have willingly given their time and the information in their possession. This review is based on the work of others, which is acknowledged with thanks. In particular, the IAG report and the Characterisation study report have been the starting point for the investigation, and most of the maps in this report are taken from the IAG maps.

For and on behalf of SRK (UK) LTD

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APPENDIX A

REFERENCES & BIBLIOGRAPHY

REFERENCES AND BIBLIOGRAPHY

This list of references will be categorised, extended and included in the final project data base.

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	DESCRIPTION	DATE	AUTHOR
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205.	A3 sections of 1/2500 topo plan showing tailings pipeline route	Undated	Unknown
206.	Mogul of Ireland Ltd., Surface Plan, 1/1200 (four sheets)	Undated	Mogul of Ireland Ltd.
207.	Mogul of Ireland Ltd. - Plan of Plant Area, 1/240	Undated	Mogul of Ireland Ltd.
208.	Mogul of Ireland Ltd. - General Geological Plan of Silvermines Area, 1/10560	Obscured	Golder Associates
209.	Old workings 45E-52E, 1/2400 (Calamine area) (shows the adit)	Undated	Not attributed
210.	Silvermines, cross sections of some underground workings	Undated	Mackay & Schnellmann Ltd
211.	Compilation geology, geophysics and geochemistry map for the Silvermines area, County Tipperary. 1:5000	Undated	Mogul of Ireland
212.	Memoir and map of localities of minerals of economic importance and matalliferous mines in Ireland.	1922	Cole, G.A.J. Memoirs of the Geological Survey of Ireland. Stationary Office, Dublin.
213.	Silvermines Lead and zinc Co., Section N71oE, Knockanroe & Ballygown South mines, 1/600 (section)	undated	Silvermines Lead and Zinc Co.
214.	Lead-Zinc Mines, Silvermines, Plan of workings, 1/600 (Ballygown)	1940	Lead-Zinc Mines
215.	Shallee Zinc Surface Plan, 1/600	1953	Shallee Zinc
216.	Silvermines Lead and Zinc Co - Shallee Mine Longitudinal Section, 00/00, 1/500	1953	Silvermines Lead and Zinc Co. Ltd
217.	Silvermines Lead and Zinc Co - Plan 4, 1/480	1954	Silvermines Lead and Zinc Co. Ltd.
218.	Assay Plan of Shallee Coughlan, 1/480	1955	Silvermines Lead and Zinc Co. Ltd.
219.	Silvermines project - Gortshanaroe & Garryard West, 1/1200 (includes subsidence)	1958	Cyrus Mines Corporation
220.	Gortnadyne 1/1200	1958	Cyrus Mines Corporation
221.	Shallee Mine, 1/480	1958	Silvermines Lead and Zinc Co. Ltd.
222.	3000 TPD Concentrator plant, Tailings disposal, tailings area, plan and typical sections, Dwg. 140-2 Rev 1 (TMF and pipeline)	1966	Mogul of Ireland Ltd.
223.	3000 TPD Concentrator plant, Tailings disposal, 8” diameter tailings line, plant to tailings area plan and profile, Dwg. 140-1 Rev 1	1966	Mogul of Ireland Ltd.
224.	County Tipperary, Sheet Tipperary XXVI-II, Geological Plan, 1/2500	1975	Mogul of Ireland Ltd.
225.	Soil Testing Program with Pionjar Drill (Gortmore tailings)	1976	None given
226.	General Mine Plan, 1/1200	1976	Mogul of Ireland Ltd.
227.	“G” Zone - 1 Level Haulage, Plan showing holing of stope into Haulage East, 1/1200	1976	Golder Associates
228.	K-Zone Dewatering, Inter Office Memorandum, 2p + 4 maps	1978	Joshi, R.V. Mogul of Ireland Ltd
229.	Section 45300E South, 1/480	1979	Mogul of Ireland Ltd.
230.	Early workings, 1/480	1979	A.B. Nichols
231.	Knight shaft, ore and waste passes, 1/480	1980	
232.	Mogul of Ireland, Ltd. - Surface Plan of "B" Zone Ventilation Raises Area, 1/240	1980	Mogul of Ireland Ltd.
233.	Overburden sampling compilation. 1:10560	1981	Irish Base Metals Ltd
234.	Cross-sections of the Silvermines area. 3p.	1981	Mogul of Ireland
235.	General Mine Plan (three sheets)	1982	Mogul of Ireland Ltd.
236.	Plan showing major development and stopes, 1/2400	1982	Mogul of Ireland Ltd.
237.	Irish Base Metals Exploration Department, Silvermines, Overburden sampling compilation (lead), 1/10560	1982	Irish Base Metals

	DESCRIPTION	DATE	AUTHOR
238.	Irish Base Metals Exploration Department, Silvermines, Overburden sampling compilation (zinc), 1/10560	1984	Irish Base Metals
239.	Irish Base Metals Exploration Department, Silvermines, Overburden sampling compilation (copper), 1/10560	1984	Irish Base Metals
240.	Irish Base Metals Exploration Department, Silvermines, Compilation go geochemical data (moil), 1/10560	1984	
241.	Silvermines CP, Surface Topography, K - Zone - Calamine Zone Compilation, 1/480	1984	Irish Base Metals Ltd., Exploration Department
242.	Silvermines CP, Compilation, 1/2400	1984	Irish Base Metals Ltd., Exploration Department
243.	Silvermines CP, Overburden Thickness	1984	Irish Base Metals Ltd.
244.	Silvermines CP, B & G Zones Ore Reserves, 1/2400	1984	Irish Base Metals Ltd.
245.	Silvermines Feasibility Study, Outline mine planning of main development, Map 1	1984	Irish Base Metals Ltd
246.	Compilation map of overburden geochemical and geophysical surveys with bedrock geology for the Silvermines licence area. 1:2500	1984	Irish Base Metals Ltd
247.	1W6 - S Stope, Surface subsidence	1984	Mogul of Ireland Ltd
248.	1W1 - S Stope/Old Shaft connection, 1/240	Undated	Mogul of Ireland Ltd
249.	Silvermines CP, Drillhole Location Plan, Gorteenadiha Zone – Surface Elevation Contours, 1/480	1985	Westland Exploration Ltd.
250.	Integrated Soil Geochemistry-Geophysics map.	1985	Westland Exploration Ltd.
251.	Mine Plan, 1/12,000	1986	Magcobar (Ireland) Ltd
252.	Silvermines CP Compilation, Gorteenadiha Zone, 34000E-42000E, 1/2400	1986	Westland Exploration Ltd.
253.	Silvermines Drillhole Compilation, 1/10560	1987	Westland Exploration Ltd.
254.	Silvermines Mineral Ownership, 1/10560	1988	Mogul of Ireland Ltd.
255.	Silvermines Mineral Ownership	1988	Mogul of Ireland Ltd.
256.	Characterisation Study of the Silvermines Area, 1/5000	2000	Natural Resource Consultant
257.	Hand annotations on 1904 1/10,000 topo plan showing archaeological sites identified by the Tipperary Heritage Officer, Duchas	2001	Dr. S. Gerraghty, Duchas

APPENDIX B

MINUTES OF MEETINGS

SILVERMINES MANAGEMENT AND REHABILITATION STUDY

NOTES FROM A MEETING AT THE OFFICES OF THE DEPARTMENT OF MARINE AND NATURAL RESOURCES (DMNR), MARCH 28, 2001, 11h00.

SRK(UK) has been appointed by DMNR to prepare a conceptual design for the management and rehabilitation of the Silvermines Mining District. As a number of Agencies are involved with this area, it was considered appropriate to hold a meeting to present the nature of the intended study to the members of the Implementation Group, Silvermines, and to exchange ideas and information.

These notes are a summary record of the meeting.

PRESENT:

Implementation Group, Silvermines:

Dr. K. Kelliher	Mid-Western Health Board
Mr. B. Condon	Teagasc
Ms. N. Flynn	Local Community Representative
Dr. P. Collery	Dept. Agriculture, Food and Rural Development
Ms. J. Brogan	Environmental Protection Agency
Mr. R Kelly	Dept. Marine and Natural Resources

Exploration and Mining Division, Dept. Marine and Natural Resources:
Mr. R. Kelly
Dr. P. Gardiner
Mr. P. Lally
Ms. L. Farrell

SRK(UK)
Dr. R. Bowell
Dr. J. Good
Dr. I. Brackley

1 INTRODUCTION	Action
The meeting was opened by Raphael Kelly, who welcomed those present, and explained the purpose of the meeting.	
2 THE SRK STUDY	
A file was handed out at the commencement of the meeting, containing a copy of the project proposal and information on the SRK Group.	
Rob Bowell gave a Powerpoint presentation of SRK's structure, experience and capabilities in relation to mine rehabilitation. Ian Brackley followed with an introduction of the project team, a description of the study and a presentation of the proposed methodology.	
The programme is:	
Phase 1 Report using available information April 19 Phase II Site work and selection of rehab options June 12 Phase 3 Conceptual design July 26	
3 CONSULTATION WITH INTERESTED AND AFFECTED PARTIES	
The proposal for a workshop of 40 participants, to have been held on April 11/12, including a site visit, was presented. This workshop will be delayed by the foot and mouth restrictions and, as an interim measure, two smaller meetings will be held. The first, the present meeting, is with the Agencies. The second, with local representatives, will be held in Nenagh on April 9 at the Abbey Court Hotel.	
It is possible that the workshop will take place towards the end of the project, and will be a report-back meeting.	I.Brackley
SRK will also meet with representatives of Magcobar and Mogul, mainly for the gathering of additional relevant information.	
4 DATA COLLECTION	
SRK will prepare a list of information and contacts for circulation to the Agencies, for the identification of omissions and other available information that can be provided.	I.Brackley
SRK has access to a large quantity of documentary information, assembled in a data room by DMNR.	
The references given in the report of the Investigation into the Presence and Influence of lead in the Silvermines area of County Tipperary (Green Report) are available on request from their various sources.	
The Groundwater section of Geological Survey is assembling information. Geoff Wright will be contacted.	L.Farrell

The identification of the Mogul and Shallee co-ordinate system may be provided by Dom O'Halloran. Mike Boland will find his telephone number. Mike Boland will also identify the person who can provide information on the Mogul underground workings. L.Farrell

EPA will send available information on sampling and testing, including work carried out since the Green Report. J.Brogan

Aerial photographs may be with the Forestry Department. Raphael Kelly will check. R.Kelly

Kevin Kelliher will be able to provide the electronic data from the study for the Green Report, including a CD ROM of the maps. This is required with some urgency, for the preparation of base plans. R.Bowell

5 AGENCY CONCERNS

There was no extensive discussion, and it was agreed that the consideration of the potential solutions would be premature.

The concern about the placement of dredged soil on the fields was mentioned, and there was some discussion of the allowable land-use.

6 AGENCY ONGOING ACTIVITIES

The EPA is continuing with sampling and testing of water and dust monitoring. The last stream samples were taken in August 2000. Samples will be taken at the school in the week of April 2-6.

The Expert Group on lead has not yet met, but will be issuing guidelines on lead in the environment.

7 CLOSURE

The meeting was closed by Raphael Kelly, with thanks to those attending.

SRK CONSULTING
SILVERMINES MANAGEMENT/REHABILITATION PROJECT
MINUTES OF A MEETING WITH LOCAL REPRESENTATIVES
ABBEY COURT HOTEL, NENAGH
APRIL 9, 2001, 7.00 pm

PRESENT:

NAME	REPRESENTING	CONTACT
Nuala Flynn	Secretary, Silvermines Environmental Action Group; Member, Inter-Agency Group	067.25472
Eamon Dooly	Vice-Chairman, Silvermines Environmental Action Group	067.25208 0872690305(mobile)
Eamon de Staffort	Archaeological interest; Shannon Development	067.25118
Pat Keane	Development Association	067.25225
Patrick Gleeson	Farmer	067.25161
Timothy Young	Kilmore Silvermines; Arrow Bawn Co-op representative	067.25213
Noel Buckley	Ex-miner	067.32068
Neil Booth	Former Mine Engineer, Magcobar Ireland Ltd	
Loreto Farrell	Department Marine and Natural Resources	
Jervis Good	Terrascope, for SRK Consulting	
Richard Connelly	SRK Consulting	
Ian Brackley	SRK Consulting	

1 PURPOSE OF MEETING

The purpose of the meeting was for the SRK team to meet local representatives, to inform them of the nature of the Silvermines management/rehabilitation study to be carried out, to elicit the concerns of the local people, and to gather additional information of relevance to the study.

2 THE STUDY

Richard Connelly of SRK described briefly the purpose of the study and the terms of reference. It was explained that the work would be carried out in three phases as follows:

Phase 1 - Review of available information and identification of all alternative solutions for the area, to be completed at the end of April. The activities included the consultation with interested and affected parties at a Study Workshop of more than thirty participants, but the foot and mouth restrictions prevented this. Instead, separate smaller meetings were to be held with the Agencies in Dublin and with local representatives in Nenagh (the present meeting). The proposed Workshop will be held at a later date as a report-back meeting.

Phase II - Site work including limited sampling and testing to confirm the results of the large amount of testing already carried out by others, and to fill any gaps. On the completion of Phase II at the end of June, the preferred options will be selected in consultation with the DMNR.

Phase 3 - Conceptual design and costing of the selected options for the individual sites, at the end of July, including:

Ballygown/Calamine
Magcobar
Mogul/Garryard
Gortmore
Shallee

And any other relevant sites identified during the study.

3 GENERAL DISCUSSION OF CONCERNS

After the description of the proposed study, the meeting was opened for the expressions of concerns and for the exchange of information. The following matters were raised, presented in the order in which they were discussed. The statements are not attributed where comments were made by several participants, but recorded for consideration during the study.

- **DUMPING OF MOGUL WASTE**
  There is an area to the south of the Mogul plant, on the south side of the main road, where Mogul dumped waste plant materials. There is also an area at Shallee Mine where Mogul dumped barrels. Material from these areas is said to be washing into the agricultural fields. Some materials in barrels was said to be buried within the Gortmore tailings impoundment.

- **DUST BLOW**
  Dust blow from Gortmore was no problem during the operating period of the mine. The blows started in April 1984, and were bad in June and July of that year. Farmers had ⅛" of dust in their houses. In 1984, there was a bad dust blow associated with frost. Shallee tailings blew in the late 1950s near the cross-roads. Several participants stated that the Gortmore tailings is still blowing, though not visibly, and reported a smell, a burning sensation on the face, and layers of dust on windows. It was considered by them that the dust monitors are not ideally-placed, and that additional positions are necessary.

- **LEAD LEVELS IN SOIL AND GRASS**
  It was said that measured lead levels in the soil are increasing in fields near the Gortmore tailings impoundment. Mrs. Ryan said that additional test results obtained independently would be made available to SRK.

- **LIVESTOCK**
  Apart from the cattle deaths due to lead poisoning, it was noted that it is not possible to keep poultry in the area, because it dies.

- **FERTILIZER**
  Conflicting advice has been given to farmers by different authorities, one saying too much phosphate is being applied, and another that not enough is being used. Mr. Young noted that milk had not been affected by contamination.

4 BALLYGOWN/CALAMINE AREA

The meeting moved to a consideration of individual areas, starting with the mining area to the south of Silvermines. Eamon de Staffort emphasised the rich mining heritage of the area, including the Cornish engine houses. It was noted that Silvermines was a planned village. The recent remedial work carried out on the school playing field and the new village walk were discussed. The possibility of a mining heritage trail was mooted. The ownership of Ballygown is unknown.

5 MAGCOBAR AREA

Most Magcobar dumps are stable and partly vegetated, but stone is still being removed from one dump, which is now a source of dust. About 450 gallons/minute was pumped from the Magcobar pit during operations.

6 MOGUL AREA

Mr. De Staffort noted that the haulage contractor now using the Mogul plant area has dug pits and is disturbing the area.

7 SHALLEE MINE AREA

Although Shallee has been identified as a possible heritage site, the surface structures are still deteriorating rapidly, because the site is open and unprotected. Old mine shafts at Shallee and elsewhere are open and unprotected, presenting a danger to children. One man was killed between Mogul and Shallee in 1957, falling down a shaft, but there have been no other fatalities or injuries.

8 YELLOW RIVER

Mrs Ryan asked about the Yellow River, which contains contaminated sediments, and asked who is responsible for dealing with this problem.

9 CLOSURE

The meeting was closed at 9pm, with thanks to all those attending. Mrs Flynn undertook to supply a list of telephone number for future contacts.

MEETING WITH FARMERS WHO HAVE HAD CATTLE DEATHS
ABBEY COURT HOTEL, APRIL 10, 2001, 9.30 pm.

Present: Ray O'Brien, Sean O'Brien (Farmer B)
P.J. Ryan (Farmer A)
I.J.A. Brackley (SRK)
Richard Connelly (SRK)
Jervis Good (for SRK)

The meeting was arranged at the request of Margaret Ryan, wife of P.J. Ryan. Mrs. Ryan had attended the meeting of SRK with local representatives on the previous evening. These notes are not complete Minutes, but are intended to convey the main points of the discussion.

Mr. Connelly described briefly the nature of the study being carried out by SRK for the DMNR, and Messrs O'Brien, O'Brien and Ryan then explained the purpose of their request for a meeting. The following paragraphs summarise their concerns.

These farmers were the "Farmer A and Farmer B" referred to in the Inter-Agency report, who had lost cattle through lead poisoning. Their present concern is that the source of their problem has not been fully acknowledged by the authorities, and that, because of this, the proposed remedial works for the Silvermines area may not adequately deal with the problem.

They understand that the stream water is normally clean, but that, if the sediments are disturbed, the particulate lead content may become dangerously high. They say that the problems with lead poisoning have always been during periods of heavy rain, when the sediment load of the streams has been high. The attached plans (to be sent with a paper copy) show the positions of the fields where the poisoning has occurred. The O'Briens assert that their poisonings have been the result of cattle drinking in the streams, rather than of eating contaminated grass.

Mr. P.J. Ryan said that most of his animals that were sent to the factory last year had elevated lead levels, and this information is available from Teagasc and the veterinary laboratory.

The main cause of the poisoning, in the opinion of these farmers, is the run-off from areas where they say that Mogul disposed of waste materials, and dust blow from Gortmore tailings impoundment. The first area is immediately south of the Mogul plant, on the opposite side of the main road. The material from this site is washed into a drainage channel beside the road during heavy rain, and is transported past the Mogul plant to join a natural stream which passes through the land of the O'Briens. The second area is within the Shallee plant area, where it is said that Mogul had dumping rights, and deposited a large number of metal drums, some containing unidentified materials. Mr. Ryan's farm is downslope of this area. He and the O'Riens also believes that the cattle deaths are at least partly a result of the dust blow.

APPENDIX C

TABLES – VEGETATION AND HABITATS

TABLE 5.9.1.

Provisional list of zones in the Silvermines area of investigation. Data from field survey, Natural Resource Consultants (2000), DAFRD (2000), other literature and press sources, and local consultation.

TABLE 5.9.2.

Sub-zones of Silvermines mine sites, with comments on vegetation cover (these are provisional, and may be revised once more data is available; because of time restrictions a more detailed survey was not possible).

TABLE 5.9.3.

Dates and approx. times, where available, of dust-blows from Gortmore TMF during the 1980s. Note that dust-blow was reported to occur intermittently throughout the summer of 1984.

TABLE 5.9.4.

Provisional incomplete list of important local species of possible use in revegetation of mine wastes to prevent dust-blow, run-off erosion and visual intrusion.

TABLE 5.9.5.

Questions arising from the preliminary information search, for Phase II. Many of these questions can be answered by further consultation with agencies and Silvermines district residents, time for which was not available during Phase I.

TABLE 5.9.6.

Incomplete provisional list of potential non-human biological impacts if inappropriate rehabilitation works were to be carried out.

TABLE 5.9.1.

Provisional list of zones in the Silvermines area of investigation. Data from field survey, Natural Resource Consultants (2000), DAFRD (2000), other literature and press sources, and local consultation.

Recent Mine Sites (Late 20^{th} century)

Mogul Site - Mogul Zn/Pb processing area, workings, buildings, waste areas and wetlands (Garryard West and Garrymore). Production ceased in 1982.

Gortmore TMF Mogul zinc/lead tailings area with polishing ponds (Gortmore). Operation ceased in 1982; revegetated in 1986-87.

Tailings pipeline 3 km pipeline route, dismantled in 1982. [Not examined]. A major spillage (polluting the Kilmastulla River) occurred in October 1980.

Magcobar Area Open pit and underground workings, rock mounds and old copper and lead workings and waste. (Gortshaneroe and Garryard West). Production ceased in 1993.

Shallee Silvermines Lead & Zinc Co. workings, buildings, tailings and waste; Mogul mine mixed refuse dump; old lead mine pits, workings, buildings and waste. (Shallee).

Old Mine Sites (19^{th} or early 20^{th} century)

Calamine Area Old calamine, lead and sulphur mine workings, buildings and waste. (Ballygown South and Knockanroe).

Gorteenadiha Old copper mine workings and waste. [Not examined due to FMD restrictions]

Shallee West Old lead mine workings and waste. [Not examined due to FMD restrictions]

Impacted Land and Waters

Grasslands Heavy metal contaminated soils from stream sediments, tailings dust and historical mine traffic. Including several groups of fields used for livestock pasture and silage production. [Not examined due to FMD restrictions].

Kilmastulla R. Heavy metal contaminated sediments and water from mine site discharges of contaminated surface and groundwater. (Incl. Yellow River, Silvermines River, Foilborrig River and other tributary streams). [Not examined due to FMD restrictions]

Subsidence areas Land (including pasture) where subsidence or collapse has occurred, or risk of subsidence or collapse is high. [Not examined due to FMD restrictions]

Geochemical Anomalies

Erinagh ?-Geochemical anomaly. [Not examined]

Sragh ?-Geochemical anomaly. [Not examined]

TABLE 5.9.2. Sub-zones of Silvermines mine sites, with comments on vegetation cover (these are provisional, and may be revised once more data is available; because of time restrictions a more detailed survey was not possible).

Mogul Site

Spillages Dump - Mostly unvegetated pyritic tailings and waste, although with vegetation on heaps of imported rubble/soil. High metal concentrations very likely. **Priority for rehabilitation/revegetation**. Plant area - Mostly unvegetated, but beneficial use does not require vegetation cover other than possibly for landscaping purposes. Metal refuse amongst western ace of yard rock waste. Railhead Beneficial use by Iarnród Eireann does not require vegetation cover, but clean-up of spillages at loading area will reduce likelihood of transfer of contaminants to surrounding vegetated areas. Settlement ponds - Area receiving drainage from plant area and overflow from road stream with little vegetation, apart from a patch of marsh vegetation with willow scrub. First pond receiving this drainage with some wetland vegetation. Second pond to east of this with diverse wetland vegetation. More data required before assessing revegetation state of these ponds. Tailings lagoon - Heaps of settlement silt/tailings are almost totally unvegetated, but the lagoon shore has c.70% marsh vegetation cover (mainly *Juncus* spp). Heaps are a **priority for rehabilitation/revegetation**. Wetlands - Several fields to the north-west of the plant area support wet grassland, scrub and marsh vegetation. Drain from settlement ponds routed through this area to pasture stream. Access pasture - From 1973 aerial photographs, it appears that some of the surrounding grassland was used for access from the plant to the tailings lagoon. The possibility of contamination of grassland soil in this area by mine traffic needs to be investigated.

Gortmore TMF

North-east Field Good vegetation cover, moss cover has developed on patches with poor grass cover; also maybe some algal binding of surface in small bare patches. North-west Field Poor vegetation cover, extensive areas of die-back due to surface acidification; small ponded water area. A strip of this area has been rehabilitated using alluvial subsoil cover (not examined). **Priority for revegetation**. West Field Vegetation cover variable, with patches of acidified surface and vegetation die-back. **Priority for revegetation**. Pond - Not examined, but winter extent covers grass which is exposed in summer. Used by swans and other waterfowl; ingestion of grit may be a problem. South Field - Mostly apparently good vegetation cover, with some degraded patches, but also a small area of colonising gorse. One plot in this area was considered to support a self-sustaining vegetation cover by Good (1999). Breeding lapwing possible. Upper Wall Slope - Very little vegetation cover remaining on east section; virtually all of this section with ochre-staining degraded surface. Many other parts of upper wall slope in similar condition, but patches (e.g. south section) appear to have reasonable vegetation cover. **Priority for revegetation**. Tailings Margin - Margin of upper surface of tailings: Areas adjoining degraded slopes are often degraded also for several m from crest. North section with thin soil cover supporting *Ulex europaeus* and with surface-dwelling earthworms. Lower Wall Slope - Mostly steep sloping unvegetated overburden rock (dolomite breccia; Natural Resource Consultants, 2000), too steep and much of area too fine-textured to revegetate with an extensive cover. However, some patches of larger rock sizes may hold soil substitute sufficient for patches of herbaceous and even scrub cover. Buffer Zone Dryland - Includes areas of gorse, briars (*Rubus* spp.), *Alnus* (?-*incana*), and rough grass cover. Buffer Zone Wetland - Varying from willow (*Salix* sp.) swamp, *Typha/Rorippa* ditches, *Juncus*/wet meadows and marsh vegetation cover (receiving drainage from TMF decant pipes). Polishing Ponds - Open water ponds surrounded by grass, briar and scrub covered walls.

Magcobar Area

Open pit Flooded pit, with mostly bare rock sides, some terraced. Potential peregrine falcon nesting habitat. Haulway Wide haul road to rock mounds with relatively good surface; little or no vegetation cover. (Includes loading bays, etc.). North Rock Mound Not examined. South Rock Mounds - Several slopes with good moss cover, with a diverse group of plant species occurring scattered amongst moss. Most slopes poorly vegetated, however. Rabbit grazing may be severe on parts of these mounds. West Rock Mounds - Southern face recently excavated for aggregate rock. **Rehabilitation priority**.

Shallee

N tailings mounds - Two benches have large areas of vegetation cover (mostly heather (*Calluna vulgaris*) on the upper bench, and wet grassland/scrub on the lower bench), as well as some unvegetated patches. The lower bench was considered the best example of self-sustaining soil/vegetation cover of any metalliferous tailings in Ireland, partly because of its relatively high water table, and partly because of the absence of highly elevated metal concentrations in the soil other than lead (Good, 1999a). S tailings mounds - More exposed, with a larger area of bare tailings surface than the N mounds, and including a small heap of wind-eroding sandy tailings. Aerial metal contamination of mosses were recorded from Shallee by Steinbörn and Breen (1999), although the exact location and potential source of dust was not given. Vegetated areas support mainly heather (*Calluna vulgaris*), although some probable marram grass (*Ammophila arenaria*) is also established, but does not seem to be spreading much (since 1991). Includes an intermittent drainage gulley. **Priority for revegetation.** Buildings area - Includes abandoned core houses, as well as concrete structures and metal structures waste, and cobble/gravel mostly unvegetated hardstanding surfaces. Mogul dump - Mixed mine waste (barrels, plastic, coarse tailings/spillage waste, organic waste material, wire rope, etc.). Drained by stream (see below). **Priority for rehabilitation.**

Spoil mounds - Old lead mine spoil mounds. Not examined in detail, but may have some botanical value as part of Mine Heritage Site nature trail. Revegetation requirements need to be assessed. Rock workings - Rock faces, pits, adits and shafts, one of which contains a pond partly filled with mixed mine waste (possibly with breeding mallard). Streams - Includes a contaminated stream flowing through the mixed waste dump, as well as another stream with waterfall and small pond near the buildings areas. **Priority for rehabilitation**.

Calamine Area

School pitch - Recently rehabilitated by Dept. of Education, with cover of c. 0.3m gravel + c.0.9m topsoil; as yet unvegetated. Fair Green - Grass cover with ornamental trees/shrubs. There is a potential problem of flooding if the open stream (draining from mine area upstream) is piped and blocked. NE triangle - Tailings mostly covered by *Agrostis* grass, moss, etc., but small bare patches of pyritic material also. Gorse (*Ulex europaeus*) on non-waste soil. Calamine/lead mine - Mid-eastern part of site. Extensive areas of bare tailings and Waelz kiln clinker, some directly above, and eroded by, Silvermines stream. Also unvegetated and partly vegetated (gorse) cobble spoil. Semi-natural diverse vegetation cover in southern part, probably on natural soil. **Revegetation priority**. SE lead mine - Includes bare tailings, with patches of gorse, *Equisetum telmateia*/grass and sycamore (*Acer pseudoplatanus*) cover. Also pond in tailings. Rehabilitation priority ? Sulphur mine - Incl. north-facing rock wall with metalliferous seepages, gorse/moss of bare clinker spoil.

Buildings area - Some open bare areas, and areas colonised by gorse (*Ulex europaeus*). Beneficial use of buildings will determine rehabilitation requirements in this area.

Kilmastulla River

(The river and its tributaries were not examined for the most part, due to access restrictions due to FMD. The following sub-zones are taken from Quirke (1999)).

Upper Foilborrig stream (south of pit)
Lower Foilborrig stream (north of pit)
Garryard stream
Upper Yellow River
Lower Yellow River
Shallee stream
Kilmastulla River (downstream from Cranna bridge)
Kilmastulla River (TMF section)
Kilmastulla River (Erinagh Bridge to TMF)
Kilmastulla River (Kilmore Bridge to Erinagh Bridge)
Sragh/Erinagh stream
Silvermines stream
Dromin tributaries (north of TMF)
Middle Shallee stream

TABLE 5.9.3. Dates and approx. times, where available, of dust-blows from Gortmore TMF during the 1980s. Note that dust-blow was reported to occur intermittently throughout the summer of 1984.

Event No.	***Dates and times***	***Weather conditions***	***Source***
1	15 April 1984		O'Meara (1985)
2	5 June 1984		Anon. (1984)
3	July, 1984	S. winds after prolonged dry weather	Anon. (1984, 1985)
4	10-(?)17 February 1985	Frost + E. wind	O'Meara (1985)
5	March 1986		Gleeson (1987)
6	11 January (18.00) -E. wind.12 January (12.00) 1987.		Gleeson (1987)

Sources:

Anon. (1984) *Tipperary Star*, 7 July 1984;
Anon. (1985) *Nenagh Guardian*, 16 February 1985;
Gleeson, P. (1987) *Nenagh Guardian*, 17 January 1987; and
O'Meara, A. (1985) *Magill*, August 1985: 24-33.

TABLE 5.9.4. Provisional incomplete list of important local species of possible use in revegetation of mine wastes to prevent dust-blow, run-off erosion and visual intrusion.

***Agrostis stolonifera* cv. 'Seaside'**

Successfully achieved self-sustaining vegetation cover in parts of the Gortmore TMF tailings (see Good, 1999b). Seed is no longer commercially available for this metal-tolerant grass, and if it is to be used in future revegetation, harvesting seed from existing swards will be necessary. It is recommended that advice is sought from Mr J.P. Timpson of Sligo IT, who co-ordinated the seed-harvesting and sowing of this variety in 1986-87.

Unidentified moss colonising bare wet tailings at Gortmore TMF (SE sub-zone)

This moss has successfully colonised large areas of Tynagh tailings (Good, 1999), and where the soil surface remains saturated, it will lay down a deep organic layer. At Tynagh there has been some invasion of this area by birch (*Betula pubescens*) and willow (*Salix* sp.). However, it is critical that the tailings surface remains saturated for this cover to be successful. Even a 5 cm marsh cover will reduce pyrite oxidation considerably (Ritcey and Silver (1987), in Ritcey, 1989).

Unidentified moss(es) colonising overburden slopes at Magcobar site (south rock mounds)

This moss or group of moss species has extensively covered parts of the slopes of some of the rock mounds, providing a germination microclimate for a diversity of vascular plants.

TABLE 5.9.5. Questions arising from the preliminary information search, for Phase II. Many of these questions can be answered by further consultation with agencies and Silvermines district residents, time for which was not available during Phase I.

Mercury - Given that there is an anecdotal seventeenth record of quicksilver having been found in the silver/lead mine (Cole, 1922), and that mercury is an Annex I element, is there any data on mercury concentrations from waste, soils or waters from the area?
Reason: Classification of contamination of land.

Moss cover - Identification required of species of moss creating extensive cover on Gortmore TMF, and on Magcobar rock mounds. Reason: Assessment of natural revegetation potential.

Algal binder - Identification required of species of algae responsible for binding surface of bare tailings in Gortmore TMF (North-east field, in particular).
Reason: Assessment of 'do nothing' option for North-east field.

Scree vegetation - Magcobar rock mound scree slope vegetation characterisation.
Reason: Assessment of natural revegetation potential.

Tailings pipeline - Route of tailings pipeline needs to be surveyed, and the location of any spillages along the route (esp. the October 1980 spillage), as well as any remaining pipes (and potential flooding if underground), needs to be ascertained. The necessity for any rehabilitation involving vegetation establishment along the route must be addressed.
Reason: Classification of contamination of land.

Silage fields - Extent to which contaminated grasslands are used for silage production, as opposed to livestock pasture only.
Reason: Assessment of food-chain uptake routes of heavy metals.
TMF NW Field Surface (0-5cm) tailings pH, EC, heavy metal and AGP (kinetic test) analyses required.
Reason: Revegetation requirements.

TABLE 5.9.6. Incomplete provisional list of potential non-human biological impacts if inappropriate rehabilitation works were to be carried out.

Livestock

Grazing cattle
(1) Increased contaminated sediment load from excavation of tailings or waste mounds bordering streams.
(2) Increased heavy metal availability from excavated stream channels.
(3) Increased heavy metal availability after traffic over contaminated pasture soils.
(4) Tailings dust generated due to inappropriate cultivation of tailings surface.

Fish

Salmon - Contamination of water in Kilmastulla River, Shallee River or Silvermines River, as a result of rehabilitation works.
Trout - Contamination of water in Kilmastulla River, Shallee River or Silvermines River, as a result of rehabilitation works.

Wildlife

Bats - Sealing shafts providing access to roosts in abandoned mines or buildings. (Bats are protected under the Wildlife Act, 1976).
Waterfowl - Lead toxicity due to use of metal-contaminated grit. (Ducks and swans).
Peregrine falcon - Disturbance of potential nesting areas in Magcobar open pit. (Peregrine falcons are protected under the Wildlife Act, 1976, and are a listed species in the Birds Directive, 1979).
Badger - Sets disturbed during excavation of scrub areas. (Badgers are a protected species under the Wildlife Act, 1976).
Lampreys - Downstream section of Kilmastulla River (where it flows into the Shannon R.) is a spawning area for these species (Kurz and Costello, 1999).(Likely to be affected only in the case of severe accidental pollution event; the habitats of lampreys are protected under the Habitats Directive).

Habitats

Metal-tolerant plant & Soil communities. Destruction of recolonised habitat during rehabilitation.

APPENDIX D

SAMPLING AND TESTING PROTOCOLS

Water Sampling Procedures

1 INTRODUCTION

These notes provide guidance for conducting the water sampling at the Silvermines site. They should be followed at each site to maintain consistency and read before any sampling preparations are made. Additional protocols are provided for the sampling of soil and waste material and for measurement of paste pH and EC.

2 PREPARATION

Before leaving to collect the water samples, the equipment listed in Table 1 should be complete.

The laboratory to be used should be contacted to supply all the relevant bottles and labels, preservatives, cooler boxes, trip blanks and Chain of Custody forms. The laboratory should also be contacted daily to organise collection of the water samples using a recognised courier.

The instruments used to measure the field parameters will be a:

Hanna HI 8424 pH, temperature and redox meter;
Hanna HI 9033 Electrical Conductivity meter;
Hanna HI 9143 Dissolved Oxygen meter;
Hach Digital Alkalinity / Acidity Test Kit; and a
Portable Spectrophotometer.

Each meter is provided with detailed calibration, storage and maintenance procedures which should be referenced before commencing sampling. Such details are not repeated here for brevity.

Where groundwater is accessible, three well volumes will need to be purged to ensure formation water is sampled. This will be undertaken using disposable bailers suspended on a length of rope. As the exact construction details of each borehole are unknown at this stage, the depth to the base of the borehole will be estimated using a water level dip meter.

Table 1 Equipment Checklist

	Description
	Sample bottles including 2 full spare sets
	Cooler Boxes and ice packs (place ice packs in freezer 8hrs before sampling)
	10% Nitric Acid
	Distilled water - 5 litres for rinsing equipment between sites
	Pipettes for dispensing 2ml of acid.
	Filter Equipment including spare hand pump and tubing
	Two boxes of filter paper 0.45µm size filter, 47mm width
	Water dip meter
	Disposable 1litre bailers for sample collection
	Thin rope for lowering bailers into boreholes (new length per borehole)
	Knife or scissors to cut the rope to length
	8mm flat screwdriver to open boreholes
	Borehole key
	Measuring meters for pH, temperature, conductivity, dissolved oxygen, redox potential and alkalinity/acidity
	Spare cartridges for alkalinity / acidity measurement
	Calibration solutions for pH, conductivity and redox probes
	Electrode cleaning solution
	Electrode storage solution
	3 x 500ml containers to collect water for field measurements
	Paper towels for cleaning and drying equipment
	Latex gloves
	Decontamination fluid (DECON 90) for cleaning
	Permanent marker pens
	Data recording sheets and pens suitable for writing outdoors
	Weatherproof case or clipboard to cover data recording sheets
	Maps and sampling protocols
	Spare batteries for dip meters and probes
	Camera and film
	Screwdrivers small enough to undo measuring meters for battery replacement
	Wrapping tape to seal the sample boxes
	Chain of custody forms
	Packing material e.g. waste paper or bubble wrap
	Courier/ transport details

3 MEASURING METER CALIBRATION

Calibration ensures the meters work properly and consistently. Calibration should be made:

- before each sampling routine;
- after 10 measurements;
- after probe replacement; and
- after battery replacement.

Detailed calibration procedures are provided in the Operation Manuals that accompany each meter. However, in order to calibrate the meters within a range suitable to the water quality to be sampled, the following calibration solutions will be required:

pH - pH 4 and pH 7 buffer solution
Electrical Conductivity – 1413µS/cm calibration solution

Fresh solution should be used for each calibration undertaken.

4 WATER SAMPLING

This section describes how to collect the samples for analysis and make field measurements.

4.1 Groundwater Purging

- Locate the borehole using the relevant site plans.
- Set up the sampling equipment a sufficient distance away from the borehole.
- Rinse the filter equipment with the distilled water and fit a filter paper so that the equipment is ready to use.
- Ensure all measuring meters are calibrated and ready for use and that the correct type and number of clean sample bottles are available.
- Once the purging is complete the sampling should commence immediately, therefore the above preparation is crucial.
- Open borehole carefully, ensuring no surface deposits enter the well
- Clean water dip meter using decontamination fluid (DECON 90) and dry with disposable paper towels.
- Slowly lower the dip meter into the well until water is encountered
- Lower and rise the tip of the dip meter to ensure the reading is of true static water level
- Record depth to water from top of borehole cover, which may be coincident with ground level.
- Rewind the dip meter taking care not to knock the internal well walls or any surface deposits with the probe..
- Using the following formula, calculate the three well volumes which need to be purged:

Volume to be purged = 3 x [(Depth of Well (m) - Depth to Water Level (m)) x 3.14 x (Well Radius (m))^2]

- Using a new disposable bailer, lower it into the well ensuring no contact with the ground surface.
- Purge the well of 3 well volumes
- Continue bailing until three well volumes have been purged
- Using the sampling connection that fits into the base of the bailer, pour water into the relevant sample bottles. Do not completely fill one bottle with the water but distribute the water between the bottles to ensure representative sample mixing.
- Repeat the procedure until all the bottles, apart from the bottle to be used for the analysis of filtered metals are full.
- Repeat the sampling procedure but this time pour water into the filter equipment and initiate filtering.
- Once filtering is complete, decant the filtered water into the filtered metals bottle.

4.2 Surface Water

- Locate the sample location using the relevant site plans.
- Set up the sampling equipment downstream of the sample site, ensuring that bank sediments are not disturbed upstream of the sampling location.
- Rinse the filter equipment with the distilled water and fit a filter paper so that the equipment is ready to use.
- Ensure all measuring meters are calibrated and ready for use and that the correct type and number of clean sample bottles are available.
- Before making the field measurements, collect the water samples.
- Water should be collected by placing the relevant sample container upside down and approximately 10cm below the water surface, then turning it to fill.
- Discard the first two volumes downstream of the sampling site.
- Following collection of samples for total metals analysis, repeat the sampling procedure but this time pour water into the filter equipment and initiate filtering.
- Once filtering is complete, decant the filtered water into the filtered iron bottle and preserve with the laboratory provided reagents.

4.3 Field Measurements

When sample collection is complete, field measurements need to be measured. The procedures apply to both surface and groundwater samples.

- Repeat the sampling procedures outlined above, but this time pour water into a container for field parameter measurement.
- Measure and record the field parameters in accordance with the instructions in the representative Operation Manuals.

- Clearly label each sample bottle with a permanent marker pen and place in a cooler box containing a frozen ice pack.
- Turn off all the measuring meters, rinse the electrodes with distilled water and replace in their respective carry cases.
- Replace any borehole cover and remove any disposable equipment from the area.

5 Quality Assurance and Control

In order to assess laboratory precision and field sampling procedures, field blanks and trip blanks should be sent to the laboratory. Label these bottles using a different borehole number or some other abbreviation, but do not indicate their blank status.

5.1 Field Blank

One field blank should be made during each sampling routine.

- Instead of filling the sample bottles fill the bottles with the distilled water used for rinsing equipment.
- Send these samples to the laboratory with the other samples.

5.2 Trip Blank

One trip blank should be made during each sampling routine.

- Prior to initiating sampling, instruct the laboratory to send a set of sample bottles filled with ultra pure HPLC water with the empty bottles for sampling.
- Carry these bottles around with all the other equipment so that they are exposed to similar environmental conditions
- Despatch the trip blanks to the laboratory at any point after day 1 of sampling

6 SAMPLE DISPATCH

When all the samples are collected, they will need to be dispatched to the laboratory in a cooler box.

- Arrange all the bottles into each sample site to ensure they are all clearly labelled and you have the correct number.
- Fill out Chain of Custody forms making sure all the samples are listed and that the number of bottles being sent is known and the correct analysis is requested.
- Place the bottles into the cooler box in an upright position, taking care with any glass bottles.
- Fill all spaces between the bottles with waste paper or bubble wrap to reduce the chance of breakage.

- If the Chain of Custody form does not have a carbon copy, photocopy and place one copy in a plastic bag in the cooler box.
- Seal the box with tape and mark 'FRAGILE' with an arrow indicating the upright position of the bottles.
- Stick an address label on the box.
- Arrange a courier with the laboratory, making sure the courier is aware the box is fragile and get a receipt for collection.

7 EQUIPMENT MAINTENANCE

Between each monitoring exercise, all equipment should be cleaned and calibrated. The sample containers and dip meter tape should be soaked in DECON 90 diluted to the manufacturers specifications. The measuring meters should be wiped clean with de-ionised water. The meter electrodes should be cleaned using the cleaning solution according to the instructions in the relevant Operation Manuals. Once cleaned, the electrodes should be stored in the relevant storage solutions.

8 PROBLEM SOLVING

This section should be referred to when there is a problem with the equipment or sampling which you can not solve.

PROBLEM	SOLUTIONS
No beep from dip meter	1. Ensure contact with water 2. Check sensitivity is set to high (+) 3. Check probe is not loose 4. Check battery connection and contacts 5. Change battery
Intermittent beep from water	1. Check probe is in the water and not bumping down the wet side of the borehole 2. Check contacts as described above
Continuous beep from dip meter	1. Ensure probe is not immersed in water 2. Check sensitivity is set to low (-) 3. Wipe probe dry and check it is not loose
Filter kit leaks	1. Stop filtering and discard water 2. Replace filter paper 3. Make sure top of filter is not loose 4. Make sure rubber washers are in position
Meter values jump randomly	1. Stir the electrode 2. Turn meter off and then back on 3. Check probe connections 4. Re-calibrate the probe 5. Replace batteries and re-calibrate

Soil Sampling Protocols

1 INTRODUCTION

These notes provide guidance for soil sampling at the Silvermines site. They should be followed at each sample location to maintain consistency and read before any sampling preparations are made. Additional protocols are provided for the sampling of water and measurement of paste pH and EC.

2 PREPARATION

Before leaving to undertake sampling, the equipment listed in Table 1 should be complete. Some of this equipment may be a duplication of what is required for the water sampling.

Table 1 Equipment Checklist

No.	Description
	Trowel
	Shovel
	Strong plastic bags – various size for soil sample
	Bag ties to seal plastic bags
	Tape measure
	Paper towels for cleaning and drying equipment
	Latex and rubber gloves
	Permanent marker pens
	Data recording sheets and pens suitable for writing outdoors
	Weatherproof case or clipboard to cover data recording sheets
	Maps and sampling protocols
	Camera and film
	Wrapping tape to seal the sample boxes
	Chain of custody forms
	Packing material e.g. waste paper or bubble wrap
	Courier/ transport details

3 SAMPLING

3.1 Surface Samples – Tailings material

- Locate the sampling location using the relevant site plans.
- If practicable, measure out an approximate 10m square in the area to be sampled
- At the corners of the square collect approximately 250g of material with the trowel to a depth of 10cm.
- Describe the material in terms of mineralogy and texture
- Place the samples from each corner in a suitable plastic bag and homogenise
- Purge all the air from the bag and seal with a bag tie
- Label clearly with a permanent marker

3.2 Sub-surface samples - Tailings material

- Locate the sampling location using the relevant site plans.

- Follow the above procedures, but instead of collecting surface soil samples collect sub surface samples by digging a pit to approximately 1m, if feasible.
- Log any changes in material with depth and photograph profile
- Collect a sample in the same way as for the surface samples at the same depth in all pits.

3.3 Surface Samples – Non tailings material

Instead of sampling on a grid basis, collect soils as and when considered applicable and representative. Follow the above procedures.

4 STORAGE AND DESPATCH

When all soils are collected, store in a cool dry place, ensuring that sharp objects can not compromise the sample bags through puncturing. Return the samples to the laboratory using a recognised courier.

Field Paste pH and Electrical Conductivity (EC) Protocols

1 INTRODUCTION

These notes provide guidance for conducting field paste pH and EC at the Silvermines site. They should be followed at each sample location to maintain consistency and read before any sampling preparations are made. Additional protocols are provided for the sampling of water and soil material.

The objectives of the test are to determine the pH and EC of pore water resulting from dissolution of secondary mineral phases on the surfaces of oxidised rock particles. The results enable assessment of whether oxidation, and accumulation of contaminants in the form of secondary mineral phases, has occurred in the waste rock prior to collection of the sample.

2 PREPARATION

Before leaving to undertake the measurements, the equipment listed in Table 1 should be complete. Some of this equipment may be a duplication of what is required for the water sampling.

The instruments used to measure the field parameters will be a:

Hanna HI 8424 pH meter; and a
Hanna HI 9033 Electrical Conductivity meter;

Each meter is provided with detailed calibration, storage and maintenance procedures that should be referenced before commencing sampling. Such details are not repeated here for brevity.

Table 1 Equipment Checklist

	Description
	Distilled water - 5 litres for creating paste
	125ml beakers or equivalent (disposable paper cups are recommended)
	Spatula and stirring rod
	Litmus paper
	Measuring meters for pH, and EC
	Calibration solutions for pH and EC meters
	Electrode cleaning solution
	Electrode storage solution
	Paper towels for cleaning and drying equipment
	Latex gloves
	Permanent marker pens
	Data recording sheets and pens suitable for writing outdoors
	Weatherproof case or clipboard to cover data recording sheets
	Maps and sampling protocols
	Spare batteries for dip meters and probes
	Camera and film
	Screwdrivers small enough to undo measuring meters for battery replacement
	Wrapping tape to seal the sample boxes
	Chain of custody forms
	Packing material e.g. waste paper or bubble wrap
	Courier/ transport details

3 MEASURING METER CALIBRATION

Calibration ensures the meters work properly and consistently. Calibration should be made:

- before each sampling routine;
- after 10 measurements;
- after probe replacement; and
- after battery replacement.

Detailed calibration procedures are provided in the Operation Manuals that accompany each meter. However, in order to calibrate the meters within a range suitable to the water quality to be sampled, the following calibration solutions will be required:

pH - pH 4 and pH 7 buffer solution
Electrical Conductivity – 1413µS/cm calibration solution

Fresh solution should be used for each calibration undertaken.

4 PASTE MEASUREMENT

- Locate the sampling location using the relevant site plans.
- Obtain approximately 25g of material from the rock sample to be tested, and place in a fresh 125ml beaker. Crush if necessary.
- Add approximately 25ml of distilled water to the sample.

- Stir sample with cleaned spatula to form a paste. The final paste should have a consistency which slides off the spatula easily.
- Tip the container to one side to allow a pool of water or slurry to collect in the corner.
- Dip the EC probes into the slurry, and allow the meter readings to stabilise and then record value.
- Dip the pH and temperature probe into the slurry, allow the meter readings to stabilise and then record the value.
- Turn off meters and rinse probes with distilled water.
- Either dispose of, or clean the beakers used

5 EQUIPMENT MAINTENANCE

At the end of each day, all equipment should be cleaned and calibrated. The sample containers should be soaked in DECON 90 diluted to the manufacturers specifications. The measuring meters should be wiped clean with de-ionised water. The meter electrodes should be cleaned using the cleaning solution according to the instructions in the relevant Operation Manuals. Once cleaned, the electrodes should be stored in the relevant storage solutions.

6 PROBLEM SOLVING

This section should be referred to when there is a problem with the equipment or sampling which you can not solve.

PROBLEM	SOLUTIONS
No beep from dip meter	1. Ensure contact with water 2. Check sensitivity is set to high (+) 3. Check probe is not loose 4. Check battery connection and contacts 5. Change battery
Intermittent beep from water	1. Check probe is in the water and not bumping down the wet side of the borehole 2. Check contacts as described above
Continuous beep from dip meter	1. Ensure probe is not immersed in water 2. Check sensitivity is set to low (-) 3. Wipe probe dry and check it is not loose
Filter kit leaks	1. Stop filtering and discard water 2. Replace filter paper 3. Make sure top of filter is not loose 4. Make sure rubber washers are in position
Meter values jump randomly	1. Stir the electrode 2. Turn meter off and then back on 3. Check probe connections 4. Re-calibrate the probe 5. Replace batteries and re-calibrate