BALLYCORUS

Background information

Mine District: Ballycorus

Mine Name: Ballycorus

Alternative Names:

Elements of interest:
Pb, Zn, Ag

Project Prefix: BCOR-

County:	**Townland:**	**Grid Reference:**
Dublin	Ballycorus	E322283, N221384

Ballycorus is located in south County Dublin, just north of the Wicklow border, 5km west of the N11. Some lead was mined here in the 19th century from an open pit but the sit was chiefly known for its smelter and shot manufactory which processed much of the lead mined in the Glendalough District (Fig. 1). The flume chimney (photo, right) is a well known south Dublin landmark and the site and its surrounds are popular with walkers. Two smaller sites to the east, Rathmichael and Barnaderg (Fig. 1), were also explored in the 19th century but apart from a hollow on the site of an old shaft there are no significant remains on these sites and they are not considered further in this report.

Geology and Mineralization

The mineralization at Ballycorus occurs within two westnorthwest – eastsoutheast-trending quartz veins that cut the Leinster Granite at its margin with the Lower Palaeozoic country rock schists (Cole 1922). The veins are typically between 0.1m and 0.6m thick, with a maximum of around 1.5m. The northern vein was the most extensively explored, with little or no excavation of the southern vein (Cole 1922). The veins coincide at the surface but diverge with increasing depth (Williams 1984). They are mainly contained within the granite but extend several metres into the wallrock schists. Mineralization was richest at the contact between granite and schist (Williams. 1984).

The primary mineralization consists of fine grained galena (PbS) mixed with sphalerite (ZnS), chalcopyrite, pyrite (FeS_2) and native silver in a quartz-barite gangue (Williams 1984). Hematite (Fe_2O_3) and secondary oxides of copper and manganese were formed at a late-stage by alteration of the primary minerals.

Production and Mining History

Mining began in the early part of the 19th century with shallow workings recorded in 1807 (Cole 1922). The early workings took place on what is now the opencast site (photo, left), located directly blow the flume chimney, apparently on a particularly rich bunch of ore, located at the contact of the granite and the schist. Subsequently the Mining Company of Ireland (M.C.I) took over the site and worked the mine intermittently between 1826 and 1863. Production of Pb rarely matched expectations, however, and the mine appears to have been a marginal proposition from the start. The best ore may well have been extracted prior to 1826. Underground mining was frequently interrupted, mainly owing to the discontinuous nature of the vein, which tended to split into thin branches, as well as fluctuating Pb prices. In 1843 a native silver vein was discovered with a length of 11m and a depth of 15m, but production was limited (Daly 1917). Mining and exploration ceased at Ballycorus in 1860 (Cole 1922).

In 1828 MCI set up smelting and rolling equipment in the valley below the mine workings. The first shot tower was constructed the following year. For most of the following 30 years the smelting works were by far the more important activity at Ballycorus, which processed ore from the company's mines in the Glendalough District and other sources. The Dublin market provided a ready-made outlet for the smelter's products. Smelting continued after mining had ceased. The flue and its chimney (photo, right) were constructed in the early 1860s to vent the smelter smoke. This smoke precipitated a Pb-rich layer on the interior walls of the flume and Pb to the value of around £1500 pa was recovered in the 1860s. Production at the smelter dropped off after 1865 and appears to have finished completely by 1914 at the latest.

Site Description and Environmental Setting

The Ballycorus site lies on the western slopes of Carrigollogan, a prominent quartzite hill formed by thrusting of the Cambrian Bray Group over the younger Ordovician schists of the along the Leinster Granite margin.. The high ground is covered in a mixture of heathland and recent commercial forestry and is a popular walking area, with forest trails traversing most of the area. The lower slopes to the west and north are mainly farmland with low-density housing situated along the roads (Fig. 1). A golf course occupies part of the eastern slopes. The mine site was located on the upper slopes at the southern end of the site. The smelter and related works were located in the valley to the north, while the shot manufactory was located halfway up the hill between the mine and the smelter (Fig. 1). The 1857 shot manufactory chimney is still standing (photo, left) and some houses and gardens are located on or beside

the site of the manufactory. Some of the houses incorporate elements of the original mine buildings (Fig. 2). The smelter site is now in use by a solvent factory (Fig. 3; photo, below left). A number of other original buildings are still visible around the site. The smelter chimney on the top of the hillside is intact as is much of the flue that carried the Pb-rich smoke to the chimney from the smelter (Fig 1). Some of the old smelter buildings are in use by the solvent factory or as residences.

The mine site is substantially overgrown by gorse and trees. There is little or no trace of the original shot manufactory built in 1829 (Fig. 2). The original opencast, developed prior to 1826, is present immediately west of the flue chimney (Fig. 2). It was partly filled in by boulders in the early 20th century (Cole 1922). Solid waste extracted from the opencast is heaped around the edge of the excavation and comprises the main volume of exposed mine waste on the Ballycorus site (SP02). Smaller solid waste heaps (SP01 and SP04) have been defined to the west, in the area around the adit and shafts near the original shot tower site (Fig. 2).

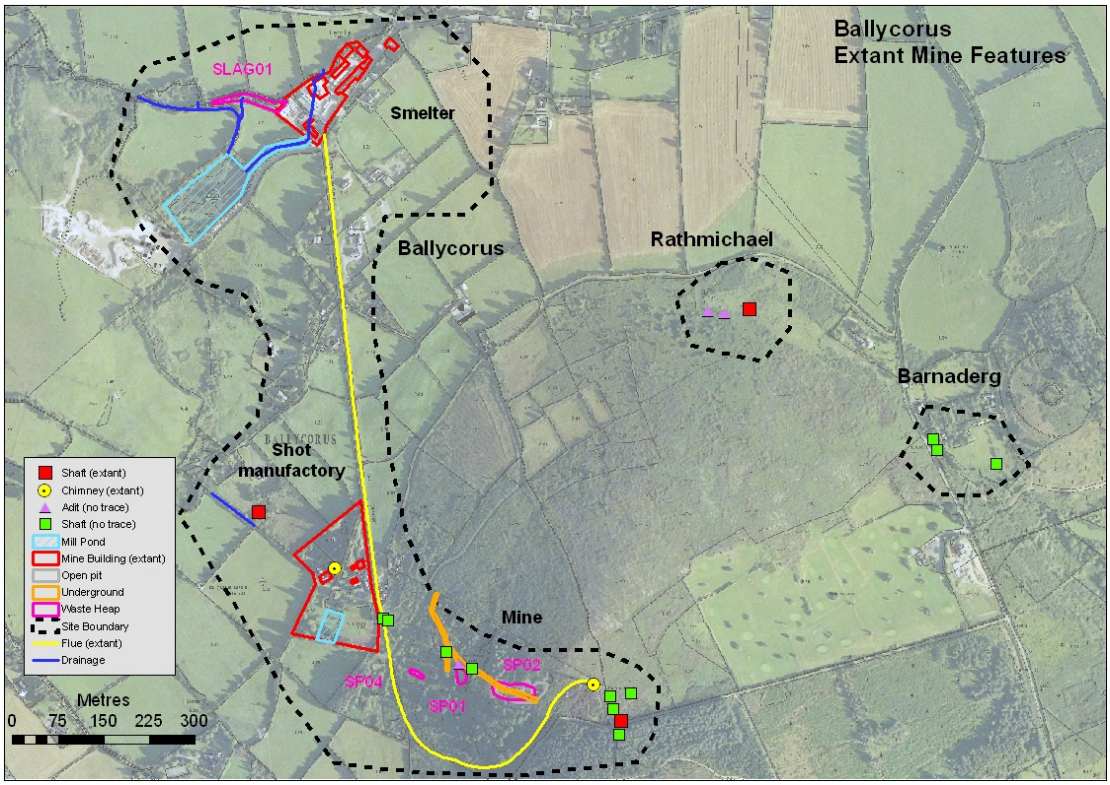

Fig. 1 Ballycorus: mine features

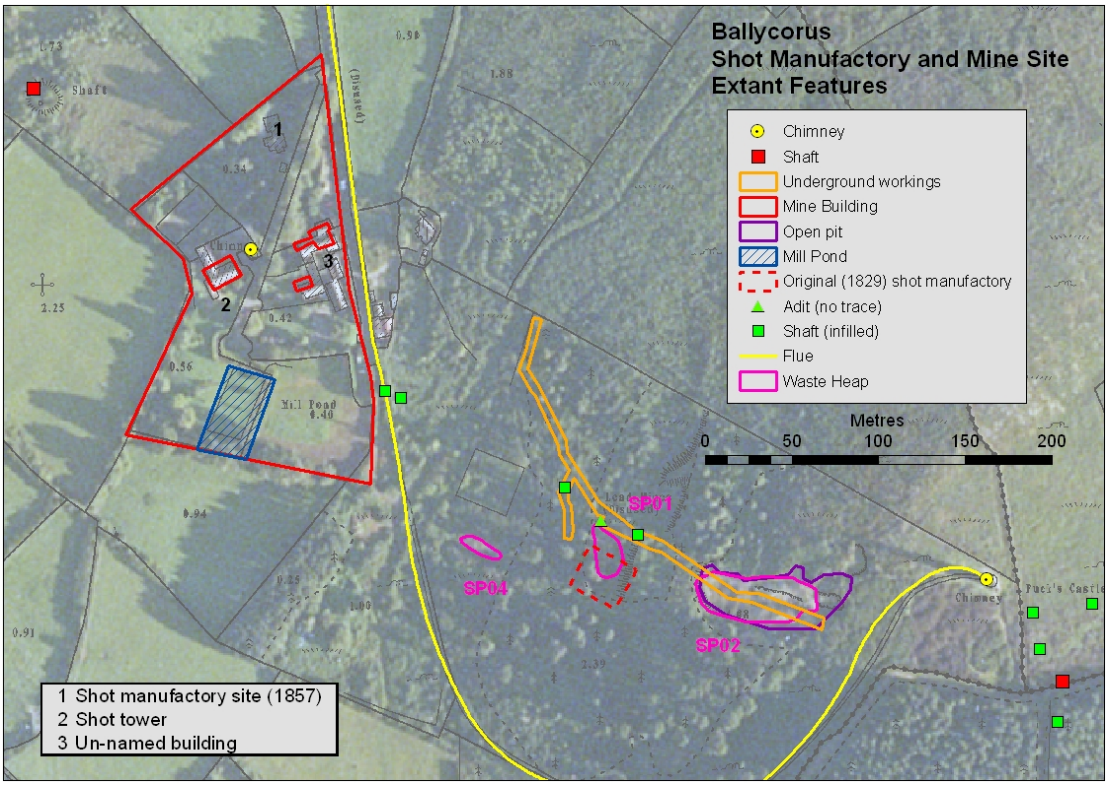

Fig. 2 Ballycorus: shot manufactory & mine site, extant features

A mill stream was used to power some of the machinery of the smelter and the remains of this are still present on the smelter site (Fig. 1). The former mill pond site is now part of a concrete plant. A waste heap on the banks of the Loughlinstown River west of the smelter buildings is composed of slag waste (SLAG01). The heap is overgrown by trees and shrubs. Table 1 shows the measured area and volume of the five solid waste heaps identified at Ballycorus.

Table 1 Ballycorus Solid Waste heaps: area and volume

Waste ID	Area (m^2)	Volume (m^3)
BCOR-SLAG01	1295	2201
BCOR-SP01	365	365
BCOR-SP02	1505	1505
BCOR-SP04	148	148

Geochemical assessment

1. Surface water

There are no mine water discharges on the Ballycorus site. The Loughlinstown River runs eastwards through the valley immediately north of Ballycorus, skirting the smelter site. Licensed discharges from the solvent factory are periodically released to the river. Five samples were taken from the river in October 2007, one upstream and the rest adjacent of downstream of the site (Fig 3; Table 2). Downstream samples had significantly higher concentrations of some elements, notably Pb and Ni (Table 2). The concentration of Pb in two downstream samples (23 and 24 µg/l) was well above the limit (7.2 µg/l) set by the Draft EC Surface water regulations. The Ni

concentration for W003 (26 µg/l) was also in excess of the Draft EC Surface water regulations limit (20 µg/l). Ni is present in high concentrations in smelter waste on the banks of the river (SLAG01, Fig. 1; see Section 4. below). Compared to metal concentrations measured downstream of some Pb mines, e.g. in the Glendalough district, the measured concentrations downstream of the Ballycorus site are modest. The lack of any direct mine drainage, such as an adit discharge, to the Loughlinstown River limits the influence of the site on the chemistry of the river water.

Table 2 Summary of surface water analyses, Ballycorus

µg/l	Pb (tot)	Cu (tot)	Zn (tot)	Ni (tot)	Ba (tot)
W005 (1.4 km u/s)	1	18	46	3	69
W004 (adj SLAG01)	2	21	69	4	79
W003 (immediately d/s)	23	20	54	26	86
W002 (1 km d/s)	1	20	61	4	87
W001 (2.4 km d/s)	24	19	60	3	91

u/s: upstream; d/s: downstream

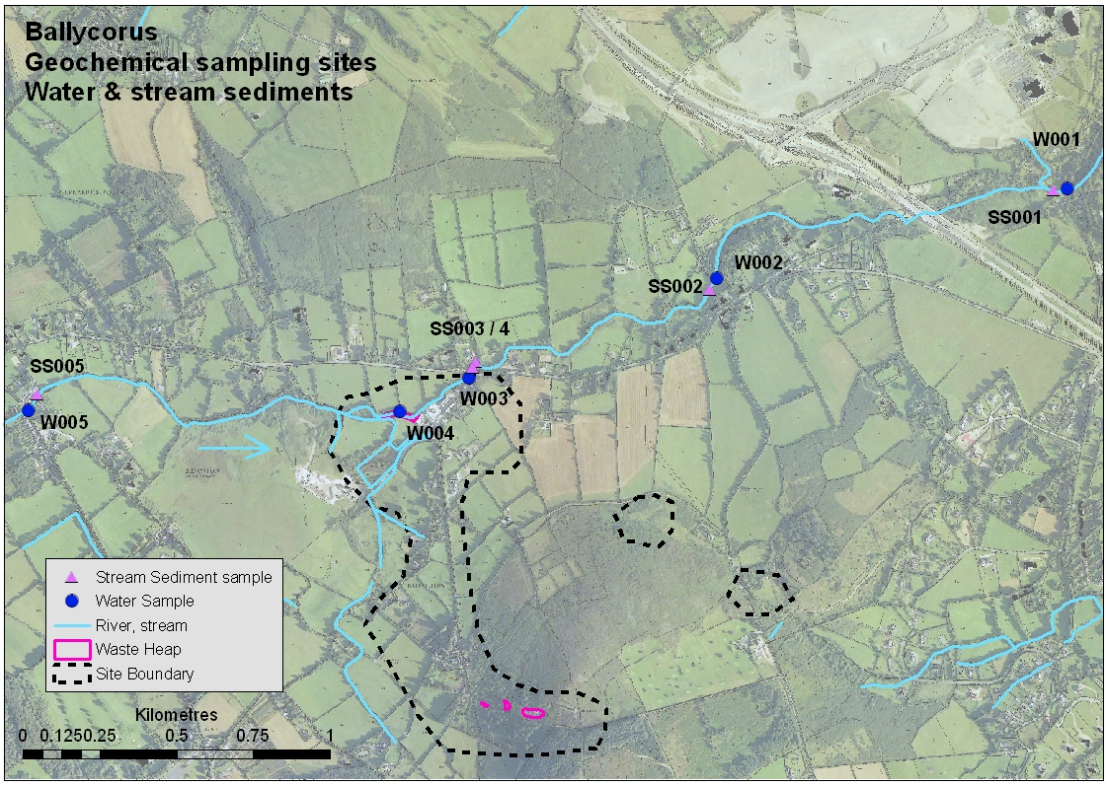

Fig. 3 Ballycorus: Geochemical sampling sites: water and stream sediments

2. Groundwater

No groundwater samples were taken at Ballycorus. Leachate tests were carried out on two composite samples of solid waste, one (BCOR-LCH001) of spoil from the waste around the old open pit (SP02) and the other (BCOR-LCH002) of slag waste (SLAG01). Leachate from the spoil samples had a high concentration of Pb (8344 µg/l) and relatively low concentrations of other elements such as Zn (76 µg/l), Cu (36 µg/l), As (1 µg/l) and Ni (2 µg/l). Slag waste leachate had a significantly lower concentration of Pb (111 µg/l) but higher Zn (376 µg/l), Cu (252 µg/l), As (4 µg/l)

and Ni (7 µg/l). The leachate data indicate that there is some potential for groundwater contamination in the vicinity of the solid waste heaps at Ballycorus.

3. Stream sediments

Stream sediment was sampled at five locations on the Loughlinstown River, close to the sites of the water samples (Fig. 3). Samples W003 and W004 were taken at the same site, immediately downstream of the smelter site. Sample W004 was a grey, sludge-like material collected just below a drainage pipe and may represent drainage from the smelter site. All samples taken downstream of the smelting site are significantly contaminated by Pb and Zn (Table 3). The measured concentration of Pb in the downstream samples ranged from 826 to 2024 mg/kg, with the highest measured concentration found 1 km downstream (W002). The same sample had the highest measured Zn concentration of 495 mg/kg. Other elements were not notably enriched in the stream sediment samples, except perhaps for one downstream sample that had relatively high Ba (Table 3). The guideline limit for Pb in stream sediments, in the context of livestock protection, is 1000 mg/kg, although this refers to the total sediment sample rather than the fine fraction.

Table 3 Summary of stream sediment analyses, Ballycorus

mg/kg	Pb	Cu	Zn	Ba
SS005 (<150 µm) (1.4 km u/s)	65	36	113	0.0
SS004 (<125 µm) (immediately d/s)	826	32	175	0.0
SS003 (<2 mm) (immediately d/s)	1061	25	203	778
SS002 (<150 µm) (1 km d/s)	2024	49	495	0.0
SS001 (<150 µm) (2.4 km d/s)	1500	45	416	0.0

u/s: upstream; d/s: downstream

4. Solid waste

Solid waste analyses were carried out *in situ* on both spoil (SP01, SP02 and SP04) and slag waste (SLAG01) at Ballycorus. In addition, grey coatings on the interior wall of the flue chimney were analysed at eight points.

The measured concentration of Pb in the coatings on the interior wall of the chimney ranged from 8700 to 224,200 mg/kg (0.87 - 22.4%). High Pb concentrations are unsurprising. During the life of the smelter, the interior wall of the flue was regularly scraped to recover Pb concentrate. Other elements detected included Zn and Cu.

Material from the waste heaps SP01 and SP02 on the old mine site were also analysed *in situ* by XRF. In addition possible material identified elsewhere on the site was also analysed as well as "soil" on the site of the 1857 shot manufactory. Table 4 summarizes the data for these samples and Fig. 4 shows the distribution of Pb. The waste on the open pit site (SP02) has very high concentrations of Pb, with a particularly high median concentration of 1.55%. Zn and Cu were also detected in significant if not particularly high concentrations. Ag was detected at low concentrations (< 40 mg/kg) in most samples, confirming its presence in the waste. Arsenic was apparently measured in most samples but comparison with laboratory check samples, analysed by ES, suggests most measured concentrations reflect peak overlap by the very large Pb peaks, giving rise to false high As. One analysis of SP02, confirmed by the external lab, gave 525 mg/kg As. Other samples analysed by the external lab all had concentrations below 100 mg/kg As.

Table 4 Summary statistics, field XRF, spoil analyses, Ballycorus

mg/kg	Pb	Zn	Cu	Ag	Ni
n	26	26	26	26	26
Minimum	1105	248	24	0.0	0.0
Maximum	47990	1597	536	39	0.0
Median	15534	798	269	23	0.0
Mean	16503	785	241	17	0.0

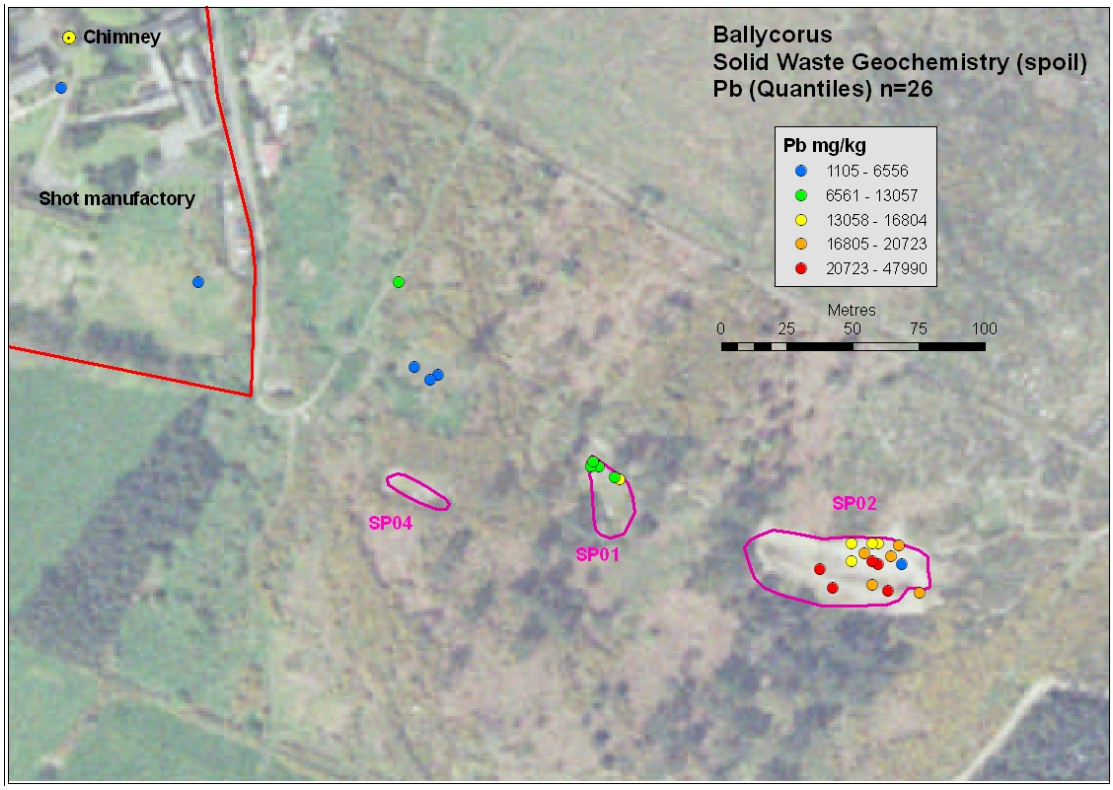

Fig. 4 Ballycorus: Distribution of Pb in solid waste, mine site

Table 5 summarizes the XRF data for the 11 sites analysed on the slag waste beside the smelter site (SLAG01). Concentrations of Pb are broadly similar to those determined for the spoil at the mine site but both Zn and Cu are present in significantly higher concentrations in slag waste. Also notable is the concentration of Ni (median 337 mg/kg) which was not detected at all in spoil. This is significant in the context of the detection of Ni in stream water immediately downstream of the smelter site and suggests the smelter waste may be having an impact on surface water chemistry in the Loughlinstown River.

Table 5 Summary statistics, field XRF, slag waste analyses, Ballycorus

mg/kg	Pb	Zn	Cu	Ag	Ni
n	11	11	11	11	11
Minimum	1460	575	207	0.0	0.0
Maximum	29102	42824	9645	35	1178
Median	19349	9452	6763	0.0	337
Mean	18312	11387	5767	11	332

5. HMS-IRC Site Score

The total HMS-IRC Site Score for Ballycorus is 244 (Table 6). The high Pb concentration of SP02 and SLAG01 as well as their higher volumes give them both higher hazard scores than the other waste heaps. The relatively large area of SP02 and its location on a site popular with visitors gives rise to an extremely high direct contact pathway score relative to the other waste heaps. The slag waste beside the smelter site has a much lower direct contact pathway score than SP02 but it still has a high total score because its proximity to the Loughlinstown River gives it a relatively high surface water pathway score (Table 6). These two waste heaps contribute almost 70% of the total site score (Fig. 5). The relatively high Pb concentration in stream sediments over an extended length of river accounts for the relatively high contribution from this source.

Table 6. HMS-IRC Site Scores, Ballycorus

Waste	**SLAG01**	**SP01**	**SP02**	**SP04**	**Stream Sediments**	**Total**
1. Hazard Score	75	41	70	41	144	371
2. Pathway Score						
Groundwater	34.49	16.78	27.68	16.78	0.00	95.74
Surface Water	23.65	3.22	5.22	2.76	0.00	34.86
Air	4.43	0.12	0.68	0.04	0.00	5.28
Direct Contact	22.09	3.31	51.59	2.48	0.00	79.47
Direct Contact (Stream Sediment)	0.00	0.00	0.00	0.00	28.79	28.79
3. Site Score	**85**	**23**	**85**	**22**	**29**	**244**

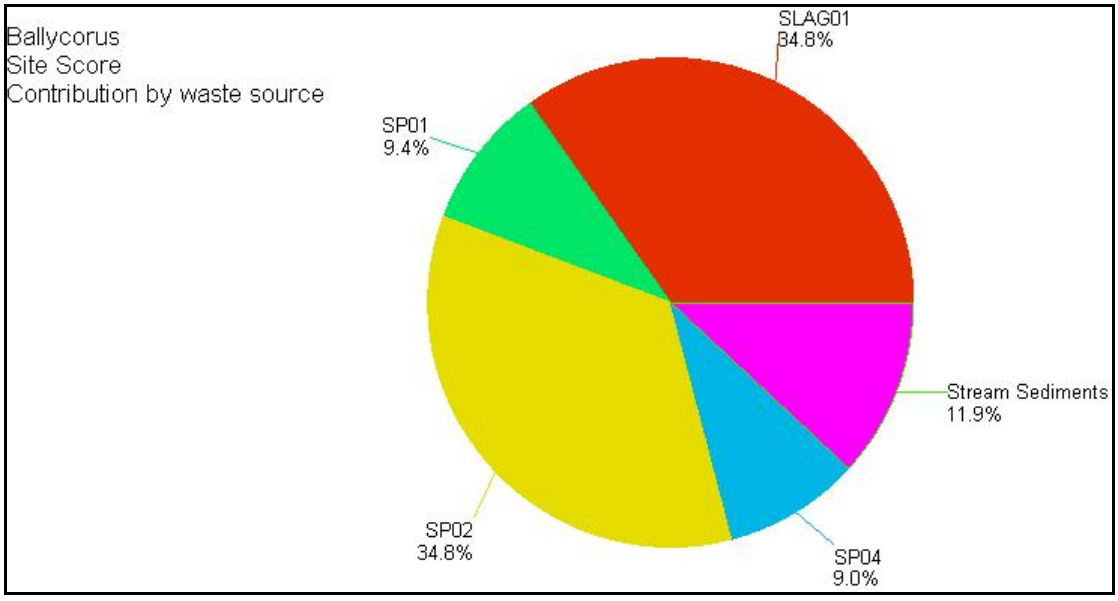

Fig. 5 HMS-IRC Site Score, Ballycorus: contribution by waste source

The pathway scores (Fig. 6) are dominated by the groundwater and direct contact pathway scores. Because the mine site is over 1 km from the Loughlinstown River, the surface water pathway (14.3%) is much less important than the groundwater pathway (39.2%) for most of the solid waste heaps. The direct contact pathway score (32.6%) is high because of the relatively large area of SP02 and its location in a highly popular recreational area.

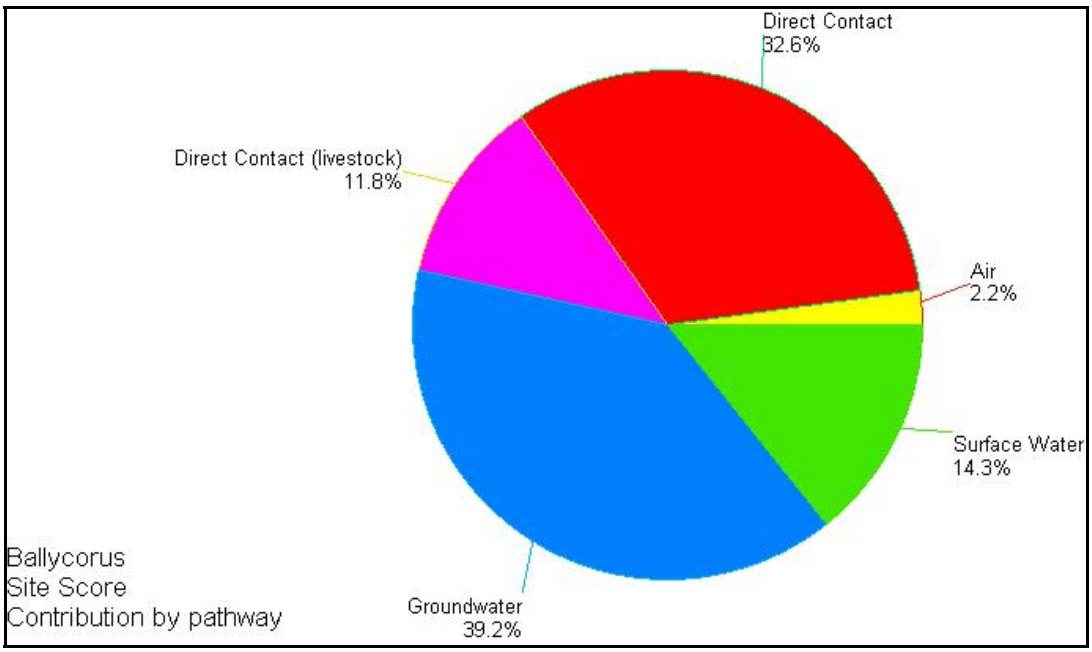

Fig. 6 HMS-IRC Site Score, Ballycorus: contribution by pathway

6. Geochemical overview and conclusions

Solid waste at Ballycorus has high concentrations of Pb, with median values exceeding 1.5% in both spoil and slag waste. The spoil is well exposed in an area popular with walkers and riders. These concentrations are in excess of guideline values or limits for soil. The inner walls of the flue chimney are partly covered with Pb-rich coatings.

Surface water analyses indicate a modest impact by the smelter / mine site on the chemistry of the Loughlinstown River, with elevated downstream concentrations of Pb and Ni, both in excess of current Draft EC Regulations for Surface Water. . Stream sediment analyses also indicate a significant downstream impact on the aquatic ecosystem, with concentrations of Pb in the fine fraction of stream sediments ranging up to 2024 mg/kg.

The HMS-IRC Site Score for Ballycorus of 244 places it in Class IV, a relatively high score for a site with only limited quantities of solid waste and no discharge of mine water.

References

Cole, G. A. J. (1922) Memoir and Map of Localities of Minerals of Economic Importance and Metalliferous Mines in Ireland.

Daly, H. J. (1917) Report upon The Ballycorus Lead Mine, Co. Dublin.

Williams, F.M. (1984) Isotopic and mineralogical studies of the Avoca stratabound sulphide deposit and brecciated sulphide-bearing veins in the Leinster Granite. Unpub. Ph.D. thesis, National University of Ireland.