BALLINAFUNSHOGE

Background information

Mine Name: Ballinafunshoge

Mine District: Glendalough

Alternative Names:

Elements of interest:
Pb, Zn, Cu, Cd

Project Prefix: GLD-

County:	**Townland:**	**Grid Reference:**
Wicklow	Ballinafunshoge	E308265, N192695

Site Description and Environmental Setting

The Ballinafunshoge site is at the southeastern end of the Glenmalure Valley, 3km northwest of Drumgoff crossroads. The site, covering approximately 12.7 ha, straddles the valley road. Most of it is steep hillside covered by forestry. The larger part of the exposed site, used for processing ore, occupies an extensive area of flat ground on the north bank of the Avonbeg River (foreground, photo, right). The remainder of the site, on the north side of the road, comprises a narrow zone of coarse waste below an adit on the steep valley side (photo, right) as well as a small area, now a car park, where several mine buildings once stood. The Glenmalure Valley is a relatively remote area with little habitation other than isolated farms. The land is used mainly for sheep pasture or commercial forestry. It is very popular with hill walkers.

The Ballinafunshoge Lode was the first to be mined in the Glendalough District. The mine commenced production possibly as early as 1797. It was certainly in production in 1800 and was worked until at least 1864, albeit with some interruptions (Cole 1922). Production varied from <100 to 400-500 tonnes per year. The lode was 3 to 5m wide and was worked to a depth of around 150m (Cole 1922). The lode consisted of quartz with the galena-sphalerite mineralization that is typical of the district. Barite was a significant component of the vein.

The processing area at Ballinafunshoge contains a large heap of coarse waste but otherwise consists of relatively flat ground covered by fine waste. A water wheel pit is the only remnant of the machinery used on the site but two areas delineated by stones may have been settling pits. A 1m-deep drainage ditch crosses the site, bringing mine water discharged from the Deep Adit to the river. The Deep Adit is located across the road from the processing site, immediately beside the base of the waste heap that covers the side of the valley. The large heap of coarse waste (centre of photo, right) has been mechanically flattened and in recent years has, along with the waste tip on the side of the valley, attracted quad bikers to the site.

The Deep Level Adit is overgrown and somewhat inaccessible; it appears to be sealed. Its location is defined by the orange-brown discharge that emerges from it. The Shallow Level Adit (photo, left) is located above the waste that covers the valley side. It is 1.6 m high at the entrance and open for at least at least 14m. Around 100m northwest of the Shallow Level Adit is a partly open shaft (un-named shaft on Fig. 1). It is partly covered by gorse but one wall is visible. The shaft is located in an area of large depressions that appear to be caved-in stopes. This area is unfenced and is immediately adjacent a popular walking track.

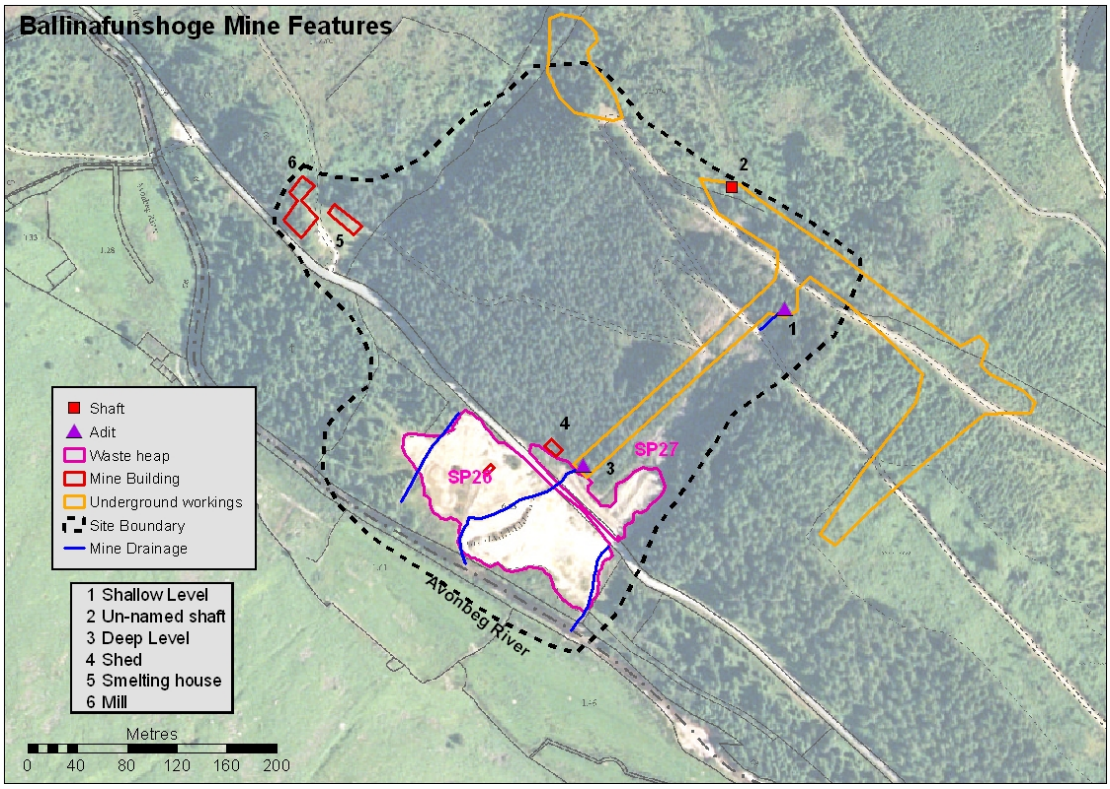

Fig. 1 Ballinafunshoge Mine Features

Only the footprints of the mine buildings remain. The shed beside the Deep Level Adit was used for cleaning ore – only a long foundation wall remains. The bases of the smelter and mill buildings are now part of a car-park and picnic area.

The solid waste at Ballinafunshoge has been subdivided into two heaps, SP26 and SP27. The main processing area is covered by SP26. This includes the large, coarse-grained tabular waste heap at the centre of the site as well as the flat area around it, consisting of fine-grained waste. The fine-grained waste includes material that resembles "tailings" or milled waste (photo, right), notably on the extreme western part of the site. Two water-filled depressions on the site may be settling ponds. The fine-grained waste on the western part of the site is generally thin. Thicknesses range up to around 0.6 m. The waste is underlain by alluvial clay and river gravels. All of the waste has undergone alteration to a greater or lesser degree and no sulphide-rich material was noted in the field. In particular, no galena-rich material was noted on the site. The waste on the side of the valley (SP27) is no more than a thin coating on the steep slope. It consists of coarse-grained material including cobbles, apparently a product of blasting. Table 1 provides an estimate of solid waste areas and volumes on the site.

Table 1 Area, volume of spoil heaps at Ballinafunshoge

Waste ID	Area (m^2)	Volume (m^3)
GLD-SP26	12651	16390
GLD-SP27	2606	5601

Geochemical assessment

1. Surface water

Water was sampled at five sites in Ballinafunshoge in both winter and summer (Fig. 2). The Deep Level Adit discharges a steady flow of mine water (sample W001) throughout the year. The flow was measured at 2.35 l/s at the beginning of March 2007 and 4.1 l/s in July 2007. The adit discharge flows in a 1m-deep channel across the processing site before joining the Avonbeg River. It was sampled again at the point just before it enters the river (W045), to see if the chemistry had changed as it flowed across the processing site. A small ditch separates the bulk of the processing site from a small area of fine tailings-like material to the west. The base of this ditch was covered in stagnant water in both winter and summer and this seepage or run-off was also sampled (W047). The Avonbeg River was also sampled, both upstream (W046) and downstream (W002) of the site. Tables 2 and 3 summarize the data for the winter and summer sampling periods.

Concentrations of Pb and Zn in the adit discharge and the seepage / run-off were very high in both summer and winter. The concentrations measured (6472 – 10140 µg/l Pb and 9065 – 15860 µg/l Zn) are the highest found in the Glendalough District and among the highest found in all Irish mine sites. Among other elements

analysed, Cu and Cd are present in elevated concentrations in mine water but are largely absent from river water (Table 2, 3). Mine water also had higher Al (743 – 5076 µg/l) than river water (254 – 850 µg/l). Despite its ochreous appearance, the concentration of Fe in the adit discharge (103 – 717 µg/l) was not notably higher than that found in the upstream river water sample (200 – 674 µg/l). There was no consistent difference in chemical composition between the two sampling sites for the adit discharge (W001 and W045), suggesting that the adit discharge does not undergo significant chemical change as it traverses the processing area. The pH of the mine water, ranging from 4.73 to 5.58, is similar to or slightly higher than that of river water; acidity is relatively low and, as is the case in both Glendasan and Glendalough, there appears to be no risk of acid mine drainage at Ballinafunshoge. ,

Ballinafunshoge is several km downstream of the Barravore mine site but the river water sample taken upstream of the Ballinafunshoge site (W046) has generally low concentrations of metals (Table 2, 3). The sample taken downstream of the site (W002) had markedly higher Pb and Zn concentrations in summer and winter, indicating significant impact from the adit discharge.

Surface water geochemistry is discussed further in the Glendalough District report.

Table 2: Summary data, water samples, November 2006, Ballinafunshoge

Sample (Fig. 2)	Flow l/s	pH	Acidity mg/l $CaCO_3$	Pb (tot) µg/l	Zn (tot) µg/l	Cu (tot) µg/l	Cd (tot) µg/
W001	2.35.	5.16	n.d.	6472	14960	42	73
W045	n.d.	5.58	n.d.	7471	13130	46	61
W047	n/a	5.02	n.d.	10140	9065	208	58
W046	n/a	5.0	n.d.	8	40	<1	<1
W002	n/a	5.18	n.d.	37	144	<1	<1

n.d.: not determined; n.a.: not applicable; flow rate for W001 determined on 01 March 2007

Table 3: Summary data, water samples, July 2007, Ballinafunshoge

Sample (Fig. 2)	Flow l/s	pH	Acidity mg/l $CaCO_3$	Pb (tot) µg/l	Zn (tot) µg/l	Cu (tot) µg/l	Cd (tot) µg/
W001	4.1	4.89	47	6512	15860	73	69
W045	n.d.	5.15	41	6280	15470	100	70
W047	n/a	4.73	39	8291	12520	224	67
W046	n/a	5.25	13	8	90	13	<1
W002	n/a	5.16	10	83	328	38	1

n.d.: not determined; n.a.: not applicable

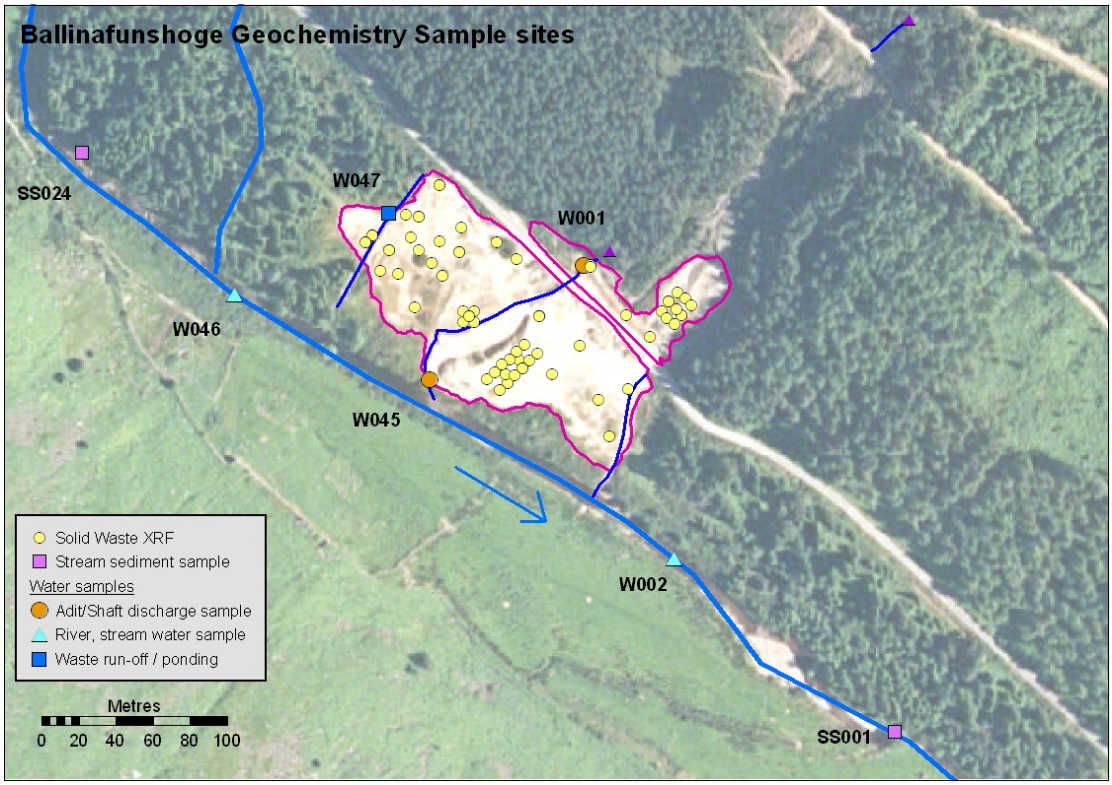

Fig. 2 Geochemical sample sites, Ballinafunshoge

2. Groundwater

No groundwater sources were sampled for the HMS-IRC project. Two composite samples, made up of various solid waste samples from SP26 and SP27, were subjected to a leachate test to determine a potential contaminated groundwater composition. The processing area sample (GLD-LCH009) had 17260 µg/l Pb, 380 µg/l Zn, 68 µg/l Cu and 3.1 µg/l Cd. The sample from SP27 (GLD-LCH010) had 15160 µg/l Pb, 102 µg/l Zn, 12 µg/l Cu and 0.4 µg/l Cd. The Pb concentration in both leachate samples is extremely high. The leachate test releases metals held in secondary phases in the waste, i.e. in phases that are readily leachable in the short, five-minute period of the test. The results thus suggest that a high proportion of Pb is present is a form that readily reacts with water, i.e. oxides and hydroxides of Pb rather than relatively insoluble galena, the original ore of Pb at Ballinafunshoge. The low concentration of Zn and Cd in the leachate compared to its relatively high concentration in the adit discharge and the seepage / run-off sample (W047) (Table 2, X.3) is similar to that observed elsewhere in the Glendalough District. Interaction between water and minerals in the waste heaps and underground is a much longer-lived process and these results suggest that under those conditions sphalerite, the main source of Zn and Cd, is leached to a greater extent.

3. Stream sediments

Stream sediment sampling is discussed in the Glendalough District report and samples from the Ballinafunshoge site are compared to those elsewhere in the district. Two stream sediment samples were collected in the immediate vicinity of Ballinafunshoge, one upstream and one downstream of the site (Fig. 2). Three

samples were collected at 1km intervals further downstream of the site. The data for Pb, Zn and Cu are given in Table 3. As Ballinafunshoge is itself downstream of the Barravore mine site the upstream sample (SS024) has a relatively high concentration of Pb (850 mg/kg) but immediately downstream of the site the concentrations was higher again (1226 mg/kg). Similarly, Zn and Cu concentrations are higher immediately downstream of the Ballinafunshoge site than upstream (Table 3), although in the case of Cu the low absolute concentrations measured suggest caution is required in interpreting the analytical data. Further downstream of Ballinafunshoge the measured Pb concentrations show a gradual decrease (Table 3). While the stream sediments in the Avonbeg River at and downstream of Ballinafunshoge are clearly contaminated by Pb and Zn, the concentrations are not in excess of levels considered safe for livestock (1,000 mg/kg and 5,000 mg/kg, respectively). However, they are likely to represent a greater risk to aquatic species and possibly birds.

Table 4: Summary statistics, stream sediments, Ballinafunshoge

Sample	Location	Pb (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
SS024	150m u/s	850	169	22
SS001	200m d/s	1226	475	31
SS005	1km d/s	862	261	28
SS002	2km d/s	623	115	28
SS027	3km d/s	494	194	<DL

4. Solid Waste

Field XRF analyses were carried out at 59 surface points on solid waste at the Ballinafunshoge site. Around half the analyses were of relatively coarse quartz- and granite-rich spoil from the large waste heap on the eastern part of the processing site and the waste covering the side of the valley (SP27). The remainder were taken on fine waste on the western side of the processing site where the processing itself was carried out. Full details of the processing that was carried out on the site were not available at the time of writing but it appears to have at least included crushing and settling. The spatial distribution of Pb in the samples is shown on Fig. 3. Tables 5 and 6 summarize the data for the main elements of interest. The major elements detected were Pb and Zn, with lesser amounts of Cu and Cd. Sulphur is present in significant concentrations in some of the processing waste samples.

Fig. 3 shows the Pb distribution on the Ballinafunshoge site. The values shown relate only to the samples from Ballinafunshoge, i.e. samples from elsewhere in the district were not included when estimating quantiles. The highest Pb concentrations were measured in process waste on the western side of the site where measured *in-situ* values exceeded 19% Pb. Concentrations of Pb in the coarse waste on the eastern part of the site are generally much lower, more typical of solid waste in the rest of the Glendalough District. Concentrations of Zn, Cu and Cd are generally much lower than those of Pb, although the maximum Zn concentration exceeds 1%. Table 6 compares the median concentrations of elements of interest for processing area waste and coarse spoil, as shown on Fig. 3. The median concentrations of Pb (3.04%) and S (0.7%) are consistent with the very high concentrations of these elements found in processing waste elsewhere in the Glendalough District. The median concentration of Zn in the processing waste is surprisingly low, however.

Table 5: Summary statistics, field XRF analyses, solid waste, Ballinafunshoge

mg/kg	Pb	Zn	Cu	Cd	S
n	59	59	59	59	59
Minimum	236	64	0.0	0.0	0.0
Maximum	194677	12548	845	238	32316
Median	11380	1375	63	48	0.0
Mean	26180	1627	120	50	4097

Note: 0.0 indicates < limit of detection

Table 6: Median values for different solid waste types, Ballinafunshoge

mg/kg (median)	Pb	Zn	Cu	Cd	S
All waste (n = 59)	11380	1375	63	48	0.0
Coarse waste (35)	7701	1476	0.0	43	0.0
Process waste (24)	30419	1215	194	61	6951

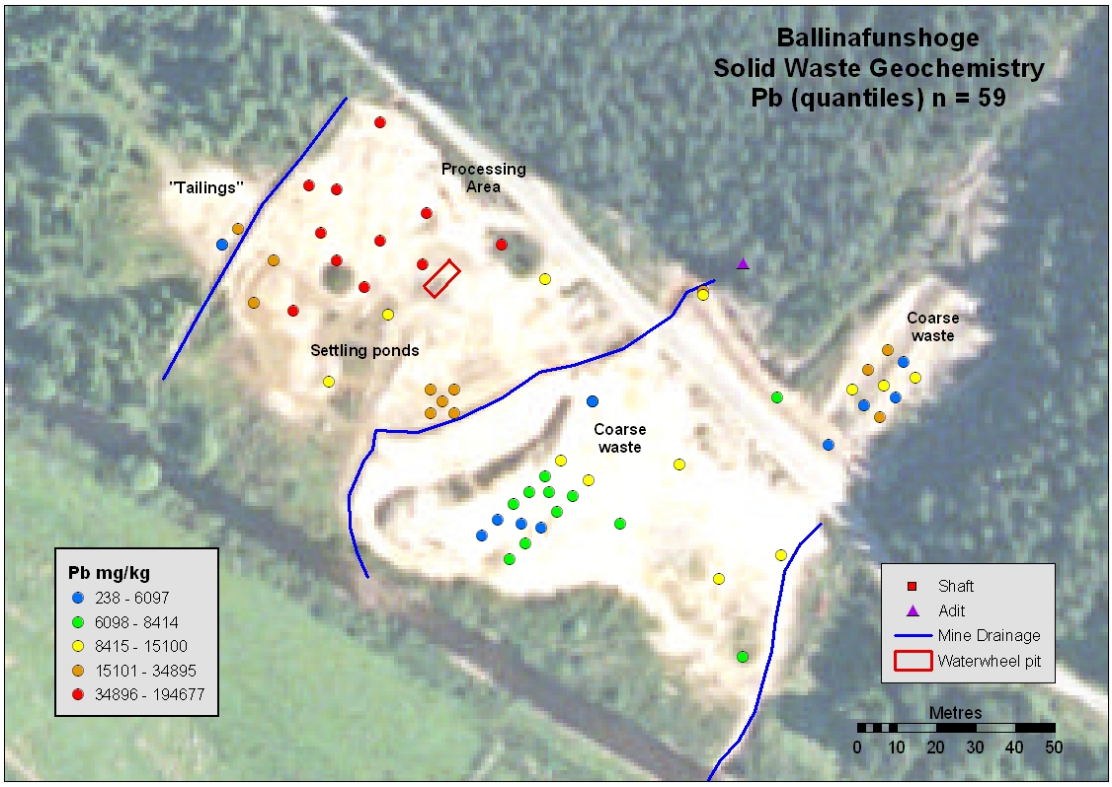

Fig. 3 Ballinafunshoge Solid Waste Geochemistry: Pb

5. HMS-IRC Site Score

The total site score for Ballinafunshoge is 305 (Table 7). The Deep Level discharge accounts for 78% of this score (Fig. 4). The solid waste heaps contribute the rest of the score, each approximately in proportion to its size. The total score for the Glenmalure Valley is 335, comprising the site scores for Ballinafunshoge (305), Barravore-Ballinagoneen (6) and stream sediments in the Avonbeg River (24). The Deep Level discharge contributes 71% of the total score and this reflects the extremely high concentrations of metals in it, especially Pb, the relatively high volume of the discharge and the greater potential impact this has on the entire range of receptors covered by the scoring system, especially the surface water of the Avonbeg River.

Table 7 HMS-IRC Site Score, Ballinafunshoge

Waste	SP26	SP27	W001	Total
1. Hazard Score	104	58	1557	1719
2. Pathway Score				
Groundwater	4.34	2.37	64.97	71.67
Surface Water	28.54	10.84	173.40	212.77
Air	2.43	0.13		2.57
Direct Contact	16.24	1.78		18.02
3. Site Score	**52**	**15**	**238**	**305**

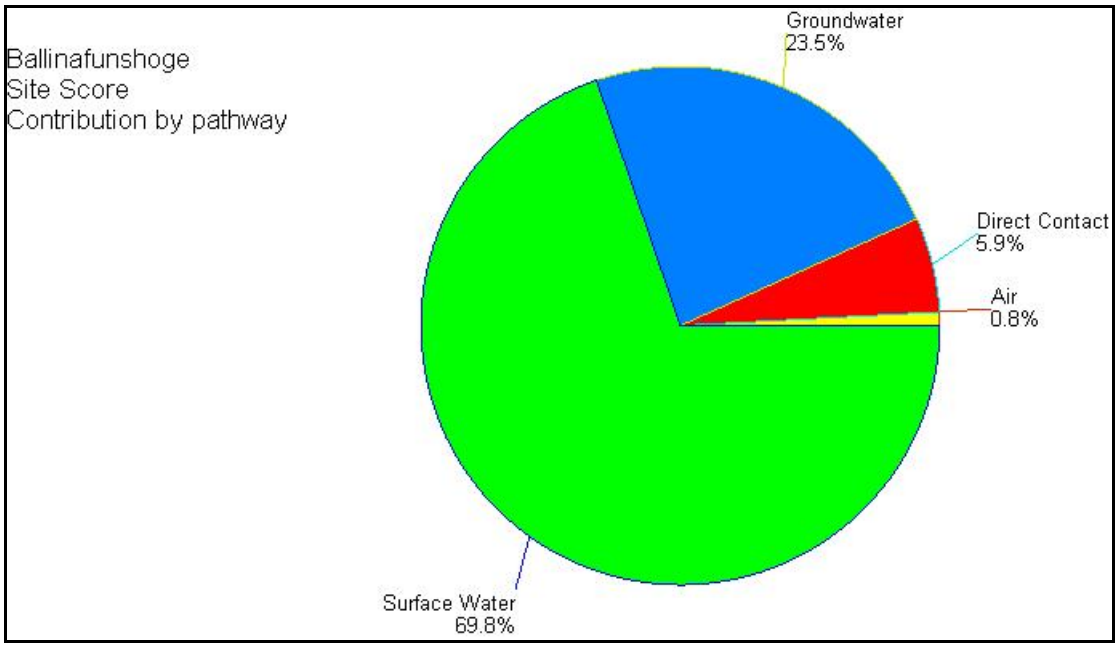

Fig. 4 HMS-IRC Site Score, Ballinafunshoge: contribution by pathway

Fig. 5 shows the contribution of the different pathways to the total site score at Ballinafunshoge. Pathways are the routes by which receptors are exposed to the hazard. Fig. 5 shows a reversal of the situation observed for Barravore-Ballinagoneen where the groundwater pathway is a much greater contributor to the site score than the surface water pathway. In Ballinafunshoge, surface water accounts for almost 70% of the score, groundwater just 23.5%. This is a consequence not only of the Deep Level discharging directly to the Avonbeg River but also of the proximity of the solid waste heaps to the river. For both heaps, the

surface water pathway score greatly exceeds the groundwater pathway score (Table 7). In the context of such high surface water pathway scores, the relatively high score for the Direct Contact pathway (18 or 5.9% of total) is notable. This high score reflects the properties of the waste on the processing site: large surface area and very high Pb concentrations combined with recreational use of the site by quad bikers.

6. Geochemical overview and conclusions

The Ballinafunshoge site is situated on the bank of the Avonbeg River. It is notable for an adit discharge that contains some of the highest concentrations of metals recorded in water samples on Irish mine sites as well as an extensive area of processing waste with very high measured concentrations of Pb and other metals. The adit discharge drains directly to the Avonbeg River and combined with run-off from the solid waste heaps has significant potential to contaminate the aquatic ecosystem. Metal concentrations in the adit discharge range up to 6,512 µg/l Pb and 15,860 µg/l Zn; even higher concentrations have been detected in run-off / seepage from the solid waste. However, the acidity of the mine water is very low and there is no risk of acid mine drainage at the site. The pH of the water in the Avonbeg River is even lower than that of the adit discharge, in consequence of extensive bogland and commercial forestry in its catchment area. The solid waste chemistry is somewhat different to that of quartz-rich mine waste found in the remainder of the Glendalough District, with significantly higher median Pb concentration (7701 mg/kg) in the coarse waste at Ballinafunshoge compared to levels of the order of 500 – 4000 mg/kg in Glendasan and Glendalough. The processing waste has some extremely high Pb measured concentrations (>19%) but Zn is not particularly enriched, its concentration exceeding 1% in only one sample of processing waste. As is the case for most sites in the district, Cd is generally present in significant concentrations in both solid and liquid waste. There is significant contamination of stream sediments downstream of the mine site, with a marked increase in Pb, Zn and Cu concentrations between the sample taken immediately upstream and that taken immediately downstream. However, stream sediments in the Avonbeg River are contaminated with Pb and Zn over the entire length between Barravore-Ballinagoneen and Drumgoff, 3km downstream of Ballinafunshoge, and no one site can be said to have caused all or even most of the contamination observed.