

FOXROCK

Background information

Mine Name: Foxrock
Mine District: Glendalough
Alternative Names:

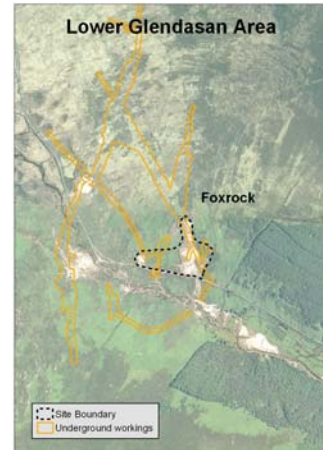
Elements of interest:
Pb, Cu, Zn, Cd

Project Prefix: GLD-

County:
Wicklow

Townland:
Brockagh

Grid Reference:
E310367, N198209



Site Description and Environmental Setting

Foxrock mine site is located on the north side of the Glendasan River, on the slope above the Wicklow Gap road (Fig. 1). It includes most of the adits and spoil heaps related to mining along the Foxrock lodes as well as the Hollyrock lode. A considerable volume of spoil lies on the steep slope above the road. Mine water discharging from two adits has formed a pond on one heap. This water then drains through the heap into a roadside drain. A number of ruined mine buildings still stand on the site. The area is popular with walkers and sightseers. The site (photo, left) covers an area of about 5.6 ha and is accessible via a track leading up from the Wicklow Gap road.



The area was first mined in the 19th century and some of the adits (3rd Adit, Hollyrock Deep Adit) were reopened and explored in the 1940s by Mianrai Teoranta. However, the only mining carried out at Foxrock in the 20th century seems to have been from the underlying 4th Adit at St. Kevin's site, south of the Wicklow Gap road.

Of the eight extant adits identified on the site (Fig. 1), five discharge mine water. The volume of water discharged by the adits ranges from less than 0.1 l/s to more than 3 l/s from the Foxrock 3rd Adit (photo, right). In each case, the mine water ultimately flows into a roadside ditch beside the Wicklow Gap road. This water then flows beneath the road and down the hillside, crosses St. Kevin's mine site and flows into the Glendasan River. Although most adits have visible openings, all have collapsed to a greater or lesser degree within metres of the entrance.



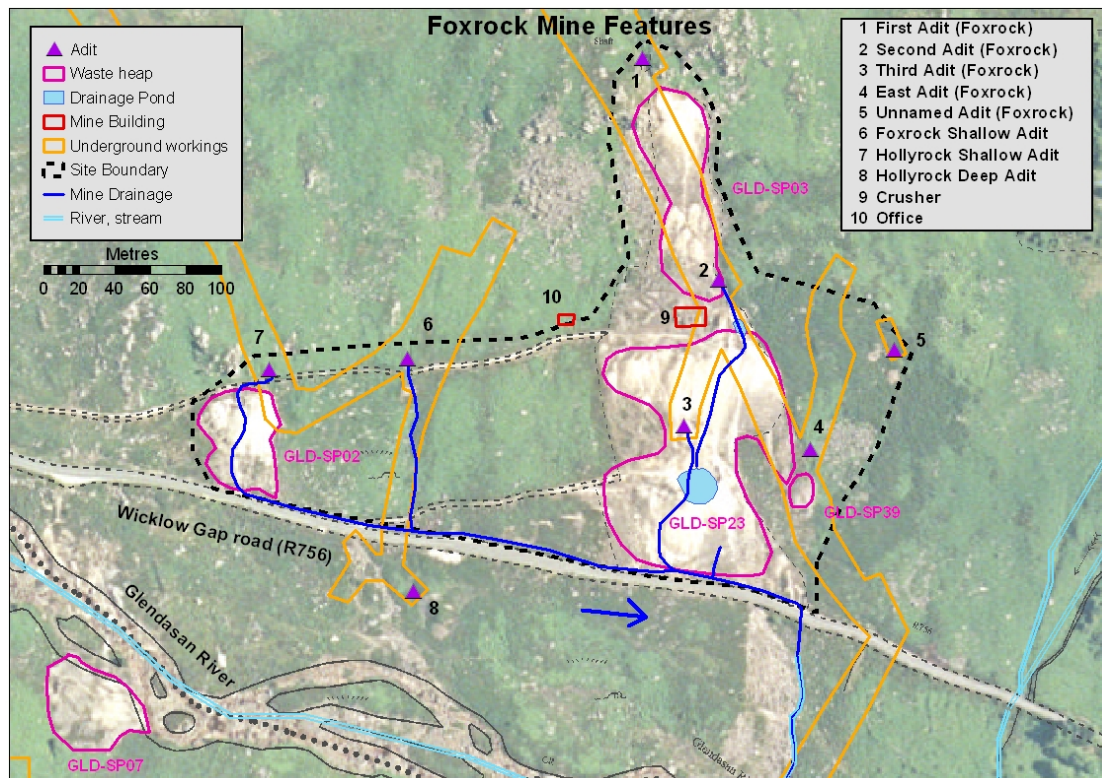


Fig. 1 Foxrock Mine Features



Two ruined two mine buildings remain on the site (Fig. 1). The main building was a crusher house (photo, left) – the remnants of thick stone walls define the footprint of the building but much of it has been reduced to a height of one metre or less. The other, smaller building, a short distance west of the crusher house, has a well preserved fireplace. This together with remnants of plasterwork suggests it was a manager's office.

The Foxrock site is notable for the significant volumes of waste that lie on the steep slope above the Wicklow Gap road. These waste heaps have been in place for many years without apparent slippage or other disturbance. However, most of the discharge from two of the adits is channelled onto the top of one heap, forming a pool that, in turn, drains through the heap before issuing as a strong seepage from the front slope of the waste heap. The percolation of significant volumes of water through the heap risks decreasing the stability of the heap. In addition to the waste heaps on the Foxrock site proper, north of the Wicklow Gap road, another heap, GLD-SP07, that lies south of the river (Fig. 1), is not part of any well-defined mine site. Therefore it has been included for convenience in the site scoring for Foxrock, The area and volume of waste heaps are given in Table 1.

Table 1 Area and volume of solid waste heaps at Foxrock

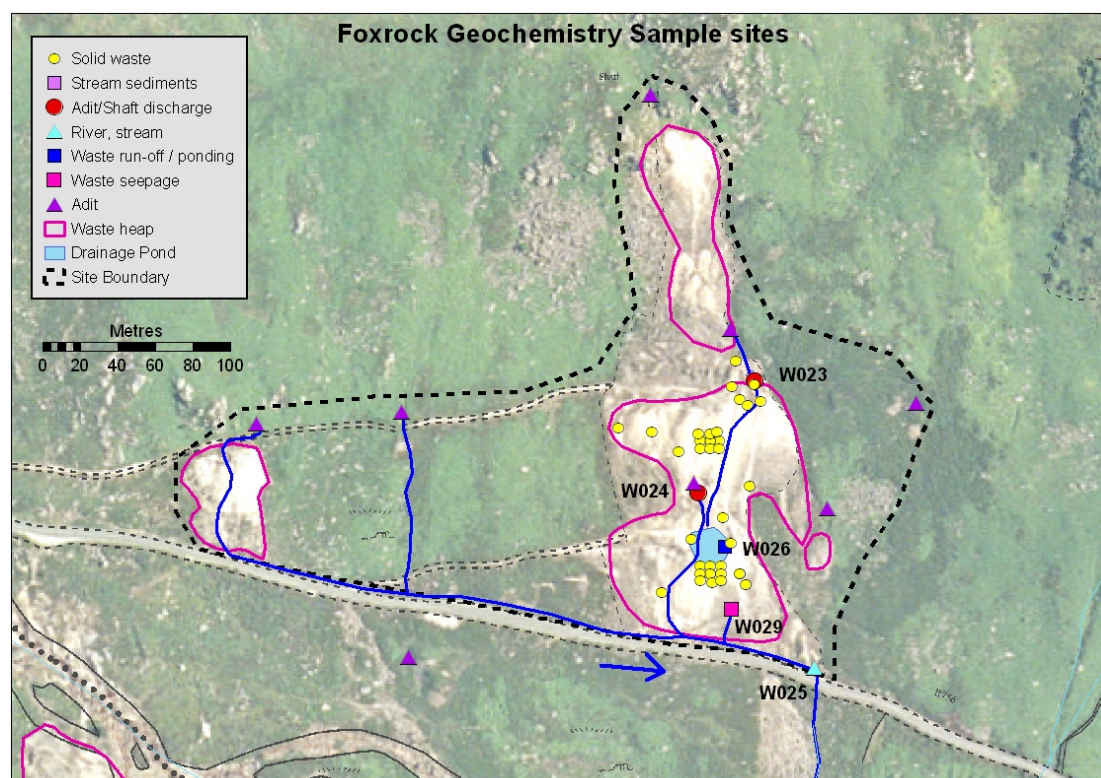
Waste ID	Area (m ²)	Volume (m ³)
GLD-SP02	2081	3238
GLD-SP03	3482	3842
GLD-SP07	2124	4488
GLD-SP23	10464	86079
GLD-SP39	210	932

Geochemical assessment

1. Surface water

All the adit discharges observed at Foxrock flow to the Glendasan River at the St. Kevin's mine site. Samples of water from the Glendasan River in the area of the St. Kevin's site had the highest metal contents of any river/stream water sampled in the district. This reflects discharges from the Foxrock adits, the adit discharge and run-off from mine waste at St. Kevin's and possibly base flow along the valley. The chemistry of the Glendasan River is described in the Glendalough District report.

Five water samples were collected on the Foxrock site in both winter (December 2006) and summer (July 2007) (Fig. 2): the 2nd Adit and 3rd Adit discharges, the drainage pond on top of waste heap GLD-SP23, the seepage emerging from the face of this heap and the water in the drainage ditch at the point just before it flows beneath the road on its way to the Glendasan River. The latter is also fed by the small discharge from the Hollyrock Shallow and Foxrock Shallow adits as well as various mountain streams.

**Fig. 2 Geochemical sample sites, Foxrock**

As indicated in the district report, the chemistry of the water samples did not vary greatly between winter and summer sampling periods. Table 2 summarizes chemical

data for the samples taken on site in December 2006. The adit discharges and the waste seepage were resampled at the beginning of March 2007 in order to measure flow rates. The flow rate included in Table 2 relates to this sampling period. Visual inspection suggests flow rates did not vary greatly between the two sampling periods. Flow rates in summer at the two adits sampled (W023 and W024) were 1.0 l/s and 3.4 l/s. The higher flow rate in W024 reflected a period of heavy rain prior to sampling.

Table 2: Summary statistics for water samples, December 2006, Foxrock

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/l
W023	1.0	6.47	8	1827	1840	13	11
W024	2.6	6.68	18	700	2739	28	17
W025	n/a	7.09	-6	409	1967	5	13
W026	n/a	7.51	-19	581	2699	17	16
W029	1.2	7.28	-13	334	2915	12	19

Note: a negative acidity reading indicates an alkalinity test result.

The data in Table 2 indicate significant Pb, Zn and Cd contents in the Foxrock adits that are carried over into the drainage stream (W025) that flows to the Glendasan River. The 2nd adit discharge has by far the highest Pb concentration but its relatively low volume means that the chemistry of the drainage pond on top of SP23 (W026) and of the seepage emerging from this heap (W029) is largely a reflection of the chemistry of the 3rd Adit discharge (W024). The measured volume of the seepage (W029) is only a fraction of the total volumes of the adit discharges because a proportion of the adit discharges flow directly to the drainage streams. The presence of Cd in the mine water is consistent with the elevated Cd values found in mine waste at other sites in Glendasan.

2. Groundwater

No groundwater sources were sampled for the HMS-IRC project. A leachate test on a spoil sample from SP23 had 2129 µg/l Pb, 582 µg/l Zn and 3.2 µg/l Cd (dissolved metal in each case). These concentrations are very similar to those obtained from a leachate test on soil at St. Kevin's mine site (see St. Kevin's site report). The Pb:Zn ratio (3.66) in the leachate differs markedly from the ratio (0.11) in the seepage (W029) that emerges from this waste heap as well as the 3rd Adit discharge (0.26) and the drainage pond on top of SP23 (0.22). While the leachate test cannot replicate precisely the natural conditions within the waste heap, the large differences observed in the Pb:Zn ratios suggest that the seepage emerging from SP23 has not undergone extensive chemical re-equilibration with the solid waste through which it has passed. In other words, the seepage retains the chemistry of its source – the 3rd Adit discharge and drainage pond formed from it. This suggests a relatively free flow of water through the waste heap.

3. Stream sediments

Stream sediment chemistry is described in the Glendalough District report.

4. Solid Waste

Field XRF analyses were carried out at 34 surface points on spoil at Foxrock mine site, mainly on SP23. Table 3 and Fig. 3 summarize the data. The major elements detected were Pb and Zn, with lesser and variable amounts of Ba, Cu and Cd.

Fig. 3 shows the Pb distribution at Foxrock. The values shown relate only to the samples from Foxrock, i.e. samples from elsewhere in the district were not included when estimating quantiles. Concentrations of Pb and Zn exceed 1% in some samples but median concentrations are similar to those found in spoil elsewhere in the district, e.g. St. Kevin's. The small concentration of Cd detected in the waste is consistent with detection of Cd in adit discharges. There is a broad linear relationship between Cd and Zn in solid waste in the Glendalough District, consistent with the presence of Cd in solid solution in sphalerite. The two metals occur in the same column of the periodic table and are isostructural. Only rarely does Cd form minerals in which it is the predominant metal – in sulphide ore deposits it is typically hosted by sphalerite.

Table 3 Field XRF data, solid waste, Foxrock

mg/kg	Pb	Zn	Cu	Cd	Ba
n	34	34	34	34	34
Minimum	1081	740	0.0	0.0	327
Maximum	12646	10237	263	60	1238
Median	4677	1549	97	38	896
Mean	5095	2500	102	33	850

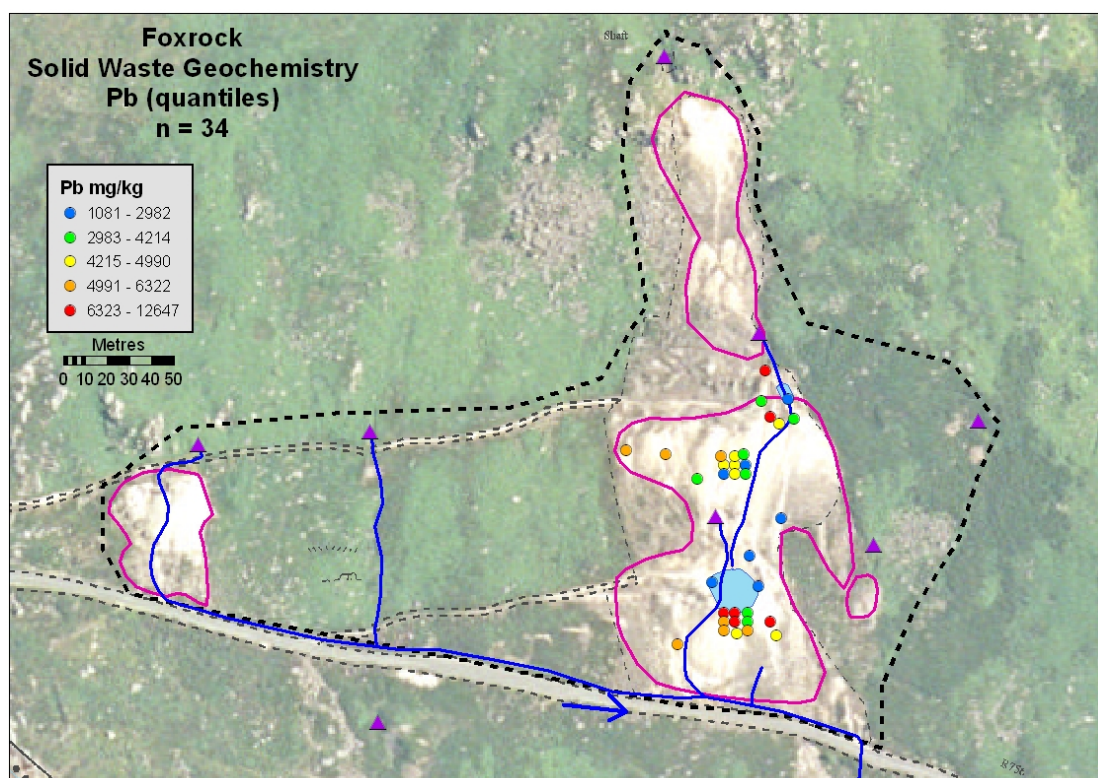


Fig. 3 Foxrock sample sites, solid waste field XRF analyses

5. HMS-IRC Site Score

The total site score for Foxrock is 197 (Table 4). The solid waste contributes 102 or 52% of the score, the mine water discharges 95 or 48%. Only one waste heap was analysed and its median chemistry has been used to score all the waste heaps at Foxrock. In consequence, the relative contribution of each heap to the score reflects its volume and surface area. The Third Adit (W024) discharges more mine water (3.4 l/s) than the Second Adit (1 l/s) but the higher concentration of Pb and Zn in the latter means its score makes up over 40% of the total discharge score.

Table 4 HMS-IRC Site Scores, Foxrock

Waste	SP02	SP03	SP07	SP23
1. Hazard Score	26	27	28	132
2. Pathway Score				
<i>Groundwater</i>	3.16	3.25	3.34	14.95
<i>Surface Water</i>	8.88	2.07	9.40	43.17
<i>Air</i>	0.08	0.08	0.08	0.83
<i>Direct Contact</i>	0.40	0.40	0.40	4.03
3. Site Score	13	6	13	63

Waste	SP39	W023	W024	Total
1. Hazard Score	22	134	183	552
2. Pathway Score				
<i>Groundwater</i>	2.70	15.79	21.48	64.68
<i>Surface Water</i>	4.15	24.39	33.20	125.25
<i>Air</i>	0.00			1.08
<i>Direct Contact</i>	0.04			5.28
3. Site Score	7	40	55	197

Fig. 4 shows the contribution of the different pathways to the total site score at Foxrock. Pathways are the routes by which receptors are exposed to the hazard. As is the case for most sites in the Glendalough District, the surface water pathway (63.8%) is the main contributor to the site score. This reflects proximity to the Glendasan River, in which the concentration of some elements exceeds the water standards, as well as factors such as poor aquifer quality and low population density, and hence few wells, that minimize the groundwater pathway score (33%). The Direct Contact pathway is low in spite of the ready accessibility of the site and the popularity of the area with tourists and walkers. This is mainly a consequence of the relatively low metal concentrations in the waste – there are no accumulations of metal-rich processing waste at Foxrock - and the relatively low surface area of the heaps.

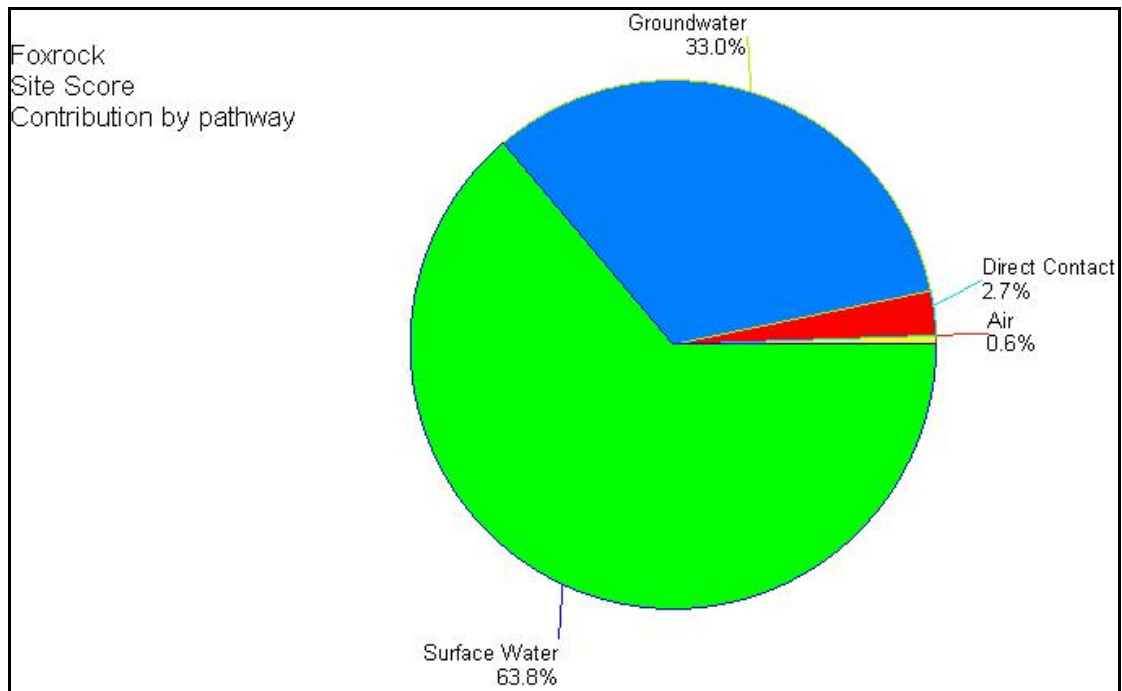


Fig. 5 HMS-IRC Site Score, Foxrock: contribution by pathway

6. Geochemical overview and conclusions

The Foxrock site contains two adits that discharge a significant quantity of mine water to the Glendasan River. Part of the discharge flows through the largest waste heap on the site, contributing to potential undermining of the heap. The 2nd and 3rd Adits have near neutral pH, low acidity and metal concentrations are of the order of 700-1,800 µg/l Pb and 1,800-2,800 µg/l Zn. The solid waste chemistry is typical of quartz-rich mine waste found in the district, with Pb concentrations typically of the order of 500 – 4000 ppm with a maximum in excess of 1%. Zn is also present in high concentrations but apart from Cd, which is typically present in concentrations below 50 mg/kg, other elements of interest are not present in significant concentrations.