

# TIGRONEY EAST

## Background information

**Mine Name:** Tigroney East

**Mine District:** Avoca

**Alternative Names:**

**Elements of interest:**

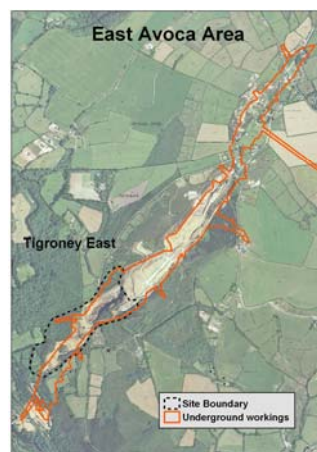
Pb, As, Cu, Zn

**Project Prefix:** AVO-

**County:**  
Wicklow

**Townland:**  
Tigroney West; Cronebane

**Grid Reference:**  
E320165, N182625



## Site Description and Environmental Setting

The Tigroney East site comprises the area between Cronebane, to the northeast, and Tigroney West, beside the Avoca River to the southwest. Tigroney East, as defined



on Fig. 1, is almost 700m long and covers 13 ha. It was the site of intensive mining, both in the 20<sup>th</sup> century and the 18-19<sup>th</sup> centuries. Extant mine features (Fig. 1) include **East Avoca Open Pit** (photo, left, view to northeast), numerous spoil heaps (photo, below), several shafts and adits, the remains of an engine house and well preserved ochre pits. The site is bordered on the northwest by heathland, pasture and the oak and mixed conifer plantations of the Castlehoward estate and on the southeast by grassland and conifer plantations. The open pit has been home to nesting peregrine falcons for many years while several species of bats have been recorded from underground workings. The site is

directly accessible by a sealed road that serves residences and farmland to the northwest. From there an unsealed track runs along the side of open pit to serve residences on the southeastern edge of the site. Wicklow County Council has installed a large boulder and a metal barrier to prevent access from there to the track that runs northeast-southwest along the southeastern boundary of East Avoca. The boulder remains in situ but the barrier has been subject to ongoing vandalism. The site has become very popular with quad bikers in recent years.



All the underground mining features on the site date from the 19<sup>th</sup> century. Of the three shafts, only Farmer's shaft is open. It is accessible via a breach in the fence surrounding it and appears to have been explored in recent years. A metal grill was installed in 2007. The other shafts have

collapsed. A 6m-diameter circular pit in Castlehoward forest, previously identified as a shaft on Wood adit (Gallagher and O'Connor 1997), may be a result of caving (CDM 2008). The air shaft on Cronebane Shallow adit is securely fenced and surrounded by spoil.

Three adits, Wood, Cronebane Shallow and North, are open to some degree. **Wood adit**, located within the oak forest of Castlehoward estate, is visible as a 5m-deep and 1m-wide trench with exposed timbering. It was the entrance to the 1.4km-long 53 fathom or Cronebane Deep level, driven in the 19<sup>th</sup> century along the entire length of Cronebane mine, i.e. to the northeastern end of Cronebane open pit. Mine water discharging from Wood adit was channelled into settling pits where iron hydroxides were separated and dried to provide ochre. These **ochre pits** are present in the forest south of the adit. **Cronebane Shallow adit** (1.3 km) was the main mining adit in use in Cronebane in the late 18<sup>th</sup> century. It is now largely silted up but discharges a low flow of AMD (c. 0.4 l/s, February 2007) from an opening 0.7m high and 0.5m wide (photo, right). **North adit** is a short (60m) adit, 1m-wide by 1.4m high, driven in the early 19<sup>th</sup> century for exploration purposes.



The open pit excavation intersected several stopes and levels: **Grass Levels adit** high on the east wall, **Cronebane Deep level** on the west and south walls and **Intermediate level** on the east wall (Fig. 1). A strong flow of AMD issues from the Intermediate adit stope (photo, left) and ponds in the pit floor before flowing into the Cronebane Deep level stope. East Avoca open pit was worked between 1978 and 1982 by Avoca Mines Ltd. in an area historically known as the "Dead Ground". It was a source of ore for the company at a time when underground mining in West Avoca was becoming increasingly problematic. Over 900,000 tonnes, grading 0.53% Cu, were mined by conventional drill/blast techniques and trucked to the mill in West

Avoca. Apart from the features already noted, the pit contains the broken rock left over after the last blast with the best examples of ore remaining on the surface at Avoca.

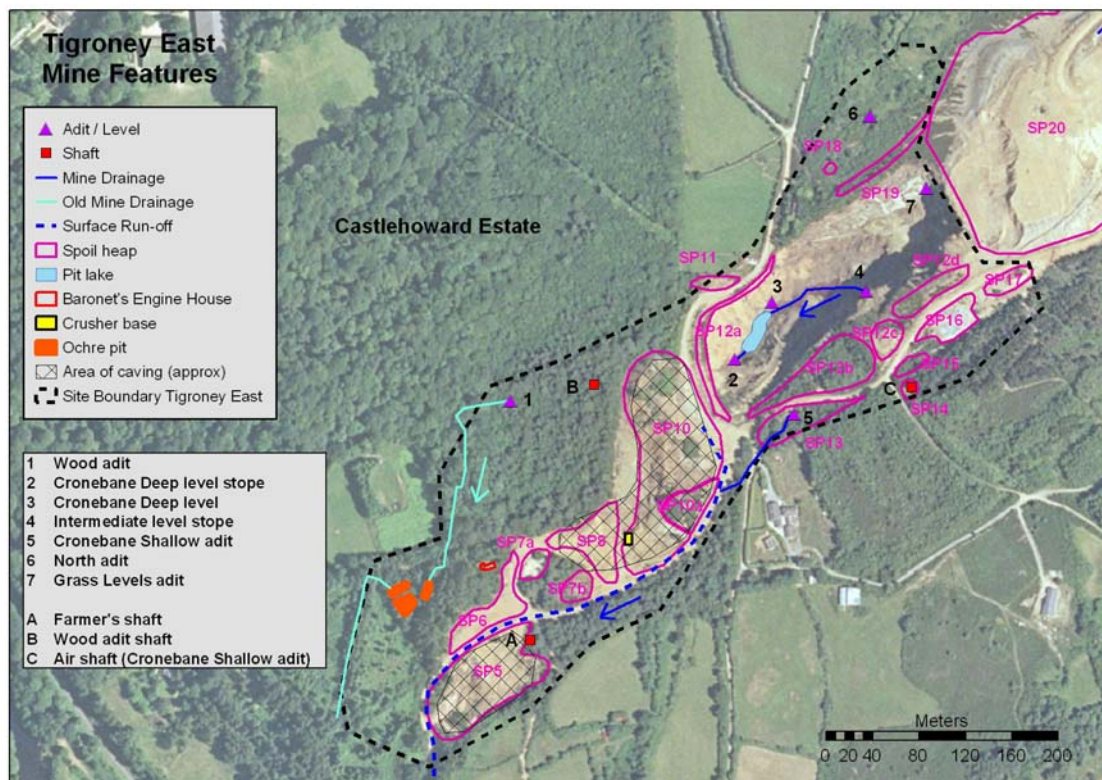
The area of Tigroney East southwest of the open pit has a dense network of underground workings. Many of these were destroyed after stope collapse led to serious caving. The caved areas (Fig. 1) have been filled with spoil. In general, like most of the Avoca mine site, Tigroney East is covered either by spoil heaps or, in between, a thin layer of spoil (Fig. 1). Although the surface is mostly bare, vegetation has taken hold in a number of places, especially where some amelioration of the surface has occurred. Amelioration has occurred in the form of dumped builder's rubble (soil with concrete neutralizing the acidic spoil and providing a growth medium), animal droppings, ash from small-scale cooking fires and organic detritus from the surrounding forests. Table 1 presents volume estimates for the spoil heaps on the site.

**Table 1 Area and volume of spoil heaps at Tigroney East**

Waste ID	Area (m <sup>2</sup> )	Volume (m <sup>3</sup> )
AVO-SP05	5,828	27,640
AVO-SP06	1629	1629
AVO-SP07a	486	364
AVO-SP07b	544	408
AVO-SP08	2002	*4028
AVO-SP10	10987	*67549
AVO-SP11	379	190
AVO-SP12a	1003	752
AVO-SP12b	2867	2150
AVO-SP12c	668	501
AVO-SP12d	1055	791
AVO-SP13	1471	1103
AVO-SP14	192	144
AVO-SP15	308	154
AVO-SP16	1196	2591
AVO-SP17	599	900
AVO-SP18	74	37
AVO-SP19	794	397

Source: HMS-IRC, modified after Gallagher and O'Connor 1997;

\* LIDAR survey 2007 (CDM Report).



**Fig. 1 Tigroney East: mine features**

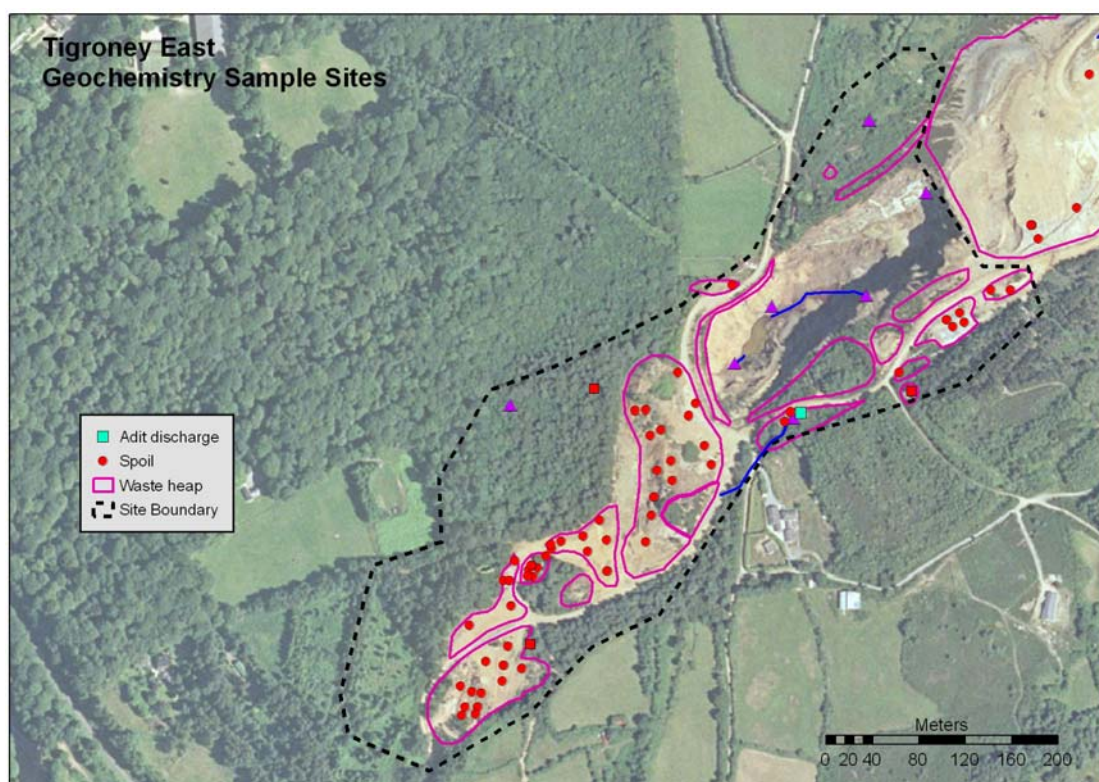
## Geochemical assessment

### 1. Surface water

The discharge from Cronebane Shallow adit was sampled in both summer and winter. The discharge within the open pit (Intermediate level) was sampled for the Avoca Feasibility Study (CDM 2008). The Cronebane Shallow adit discharge has some of the highest metal concentrations recorded at Avoca as well as the highest acidity and lowest pH (2.6) (Table 2). Metal concentrations bear comparison with those recorded from seepages at Mount Platt (Cronebane site report). However, the volume discharged from Cronebane Shallow adit is relatively small, the highest flow recorded during the project being 0.38 l/s in February 2007. Moreover, it appears to flow back into the underground workings, mixing with other mine drainage before emerging as part of the Deep adit discharge in Tigroney West. Concentrations recorded in the Intermediate level discharge are more modest but the flow is much higher. This discharge drains directly back into the underground workings at the southwest end of the open pit.

**Table 2: Data for surface water, Tigroney East**

	Pb (tot) µg/l	Zn (tot) µg/l	Cu (tot) µg/l	As (tot) µg/l	Cd (tot) µg/l	Cr (tot) µg/l	Acidity Mg/l CaCO <sub>3</sub>
Cronebane Shallow Feb 2007	835	62010	10720	14	251	14	2400
Cronebane Shallow June 2007	1197	110500	8361	3	317	14	3400
Intermediate level July 2007 (CDM)	1109	28800	2569	1	107	4	670



**Fig. 2 Tigroney East: Geochemical sampling sites**

## 2. Groundwater

No groundwater sources were sampled for this site. Three leachate samples, each consisting of spoil taken from a number of heaps in the area, had high levels of dissolved Cu (146 – 2307 µg/l), Pb (1614 – 6302 µg/l) and Zn (408 – 4915 µg/l) and somewhat elevated Cd (1.4 – 12.9 µg/l) and Ni (15 – 19 µg/l). The potential for contamination of groundwater by leachate from waste heaps is clear although, in Tigroney East, as elsewhere in Avoca, leachate appears to drain to the existing underground workings or else drains directly to the Avoca River either as surface run-off or as base flow.

## 3. Stream sediments

No stream sediments were sampled in the Tigroney East area. Sampling took place on the Avoca River and Sulphur Brook stream. Details are provided in the Avoca District report.

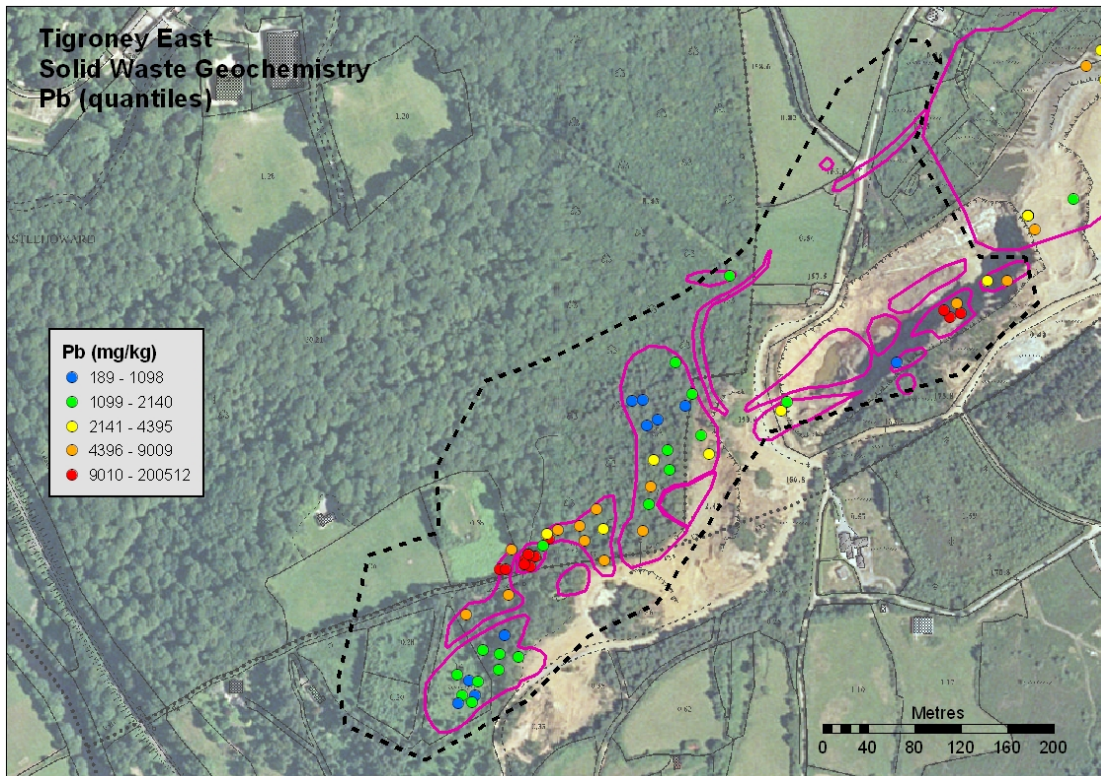
## 4. Solid Waste

Eighteen separate waste heaps have been defined for the Tigroney East site (Fig. 1) (Gallagher and O'Connor 1997). Field XRF analyses were carried on 10 of these heaps in June 2007 although in some cases only one or two spots were analysed (Fig. 2). In Fig. 3 and Table 3, the concentration of Pb and other elements of interest are compared to those for other spoil samples at Avoca. Median concentrations of Pb, As and Zn are somewhat lower than the median values for the remainder of analysed spoil in Avoca but median Cu concentration is higher (Table 3). Although the concentration of Pb is generally a little lower than elsewhere in Avoca, Tigroney East does contain the waste heap with the highest recorded Pb value, SP16 (Fig. 1). Part of this heap is a fine metal-grey waste, with sulphur-yellow oxidation crust. It yielded over 20% Pb and 5% S in one field XRF analysis, suggesting it is a galena-rich material, possibly kilmacooite as found in Connary. It also contained the highest Cu value (14,357 mg/kg) recorded in field analyses at Avoca. This is reflected in the Site Score for this waste heap (section 5, below).

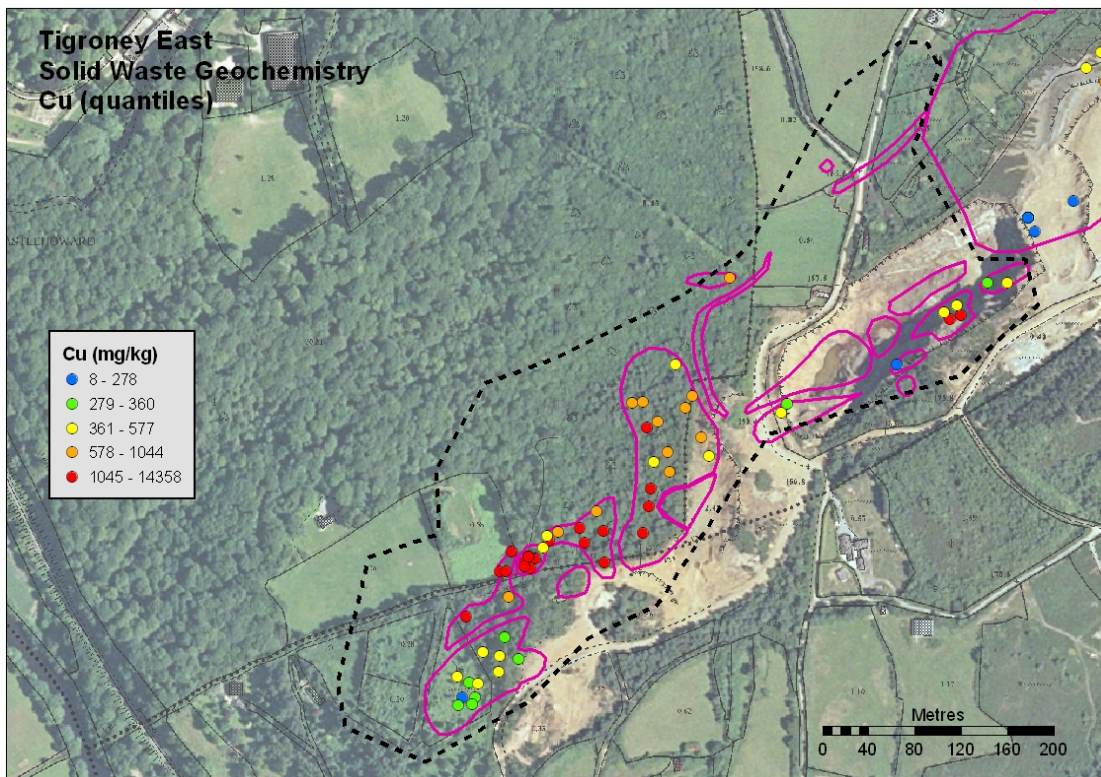
Other relatively high Pb values are clustered in the area of Baronet's engine house (SP6, SP7). Ore was raised here along Baronet's shaft, the site of which is now covered by spoil. This area also has a cluster of high Cu values (Fig. 4) which supports the idea that spoil here is the residue of Cu ore raised here in the 19<sup>th</sup> century. The area of cavity fill (SP05) is notable for low Pb and Cu values, suggesting the use of low-grade waste to fill the collapse zone.

**Table 3: Summary statistics, field XRF analyses of solid waste, Tigroney East**

mg/kg	Pb	As	Sb	Cu	Zn
n	58	58	58	58	58
Minimum	461	56	0.0	214	0.0
Maximum	200512	10316	1629	14358	12177
Mean	9955	886	97	1257	435
Median	2384	441	0.0	739	73
Median rest Avoca spoil (n=172)	2856	750	0.0	382	117



**Fig. 3 Tigroney East: Solid Waste Field XRF Geochemistry: Pb**  
(Note that quantile values listed in Legend relate to all Avoca spoil analyses)



**Fig. 4 Tigroney East: Solid Waste Field XRF Geochemistry: Cu**  
(Note that quantile values listed in Legend relate to all Avoca spoil analyses)

## 5. Site Scores

**Table 4 Site Scores for mine waste, Tigrone East**

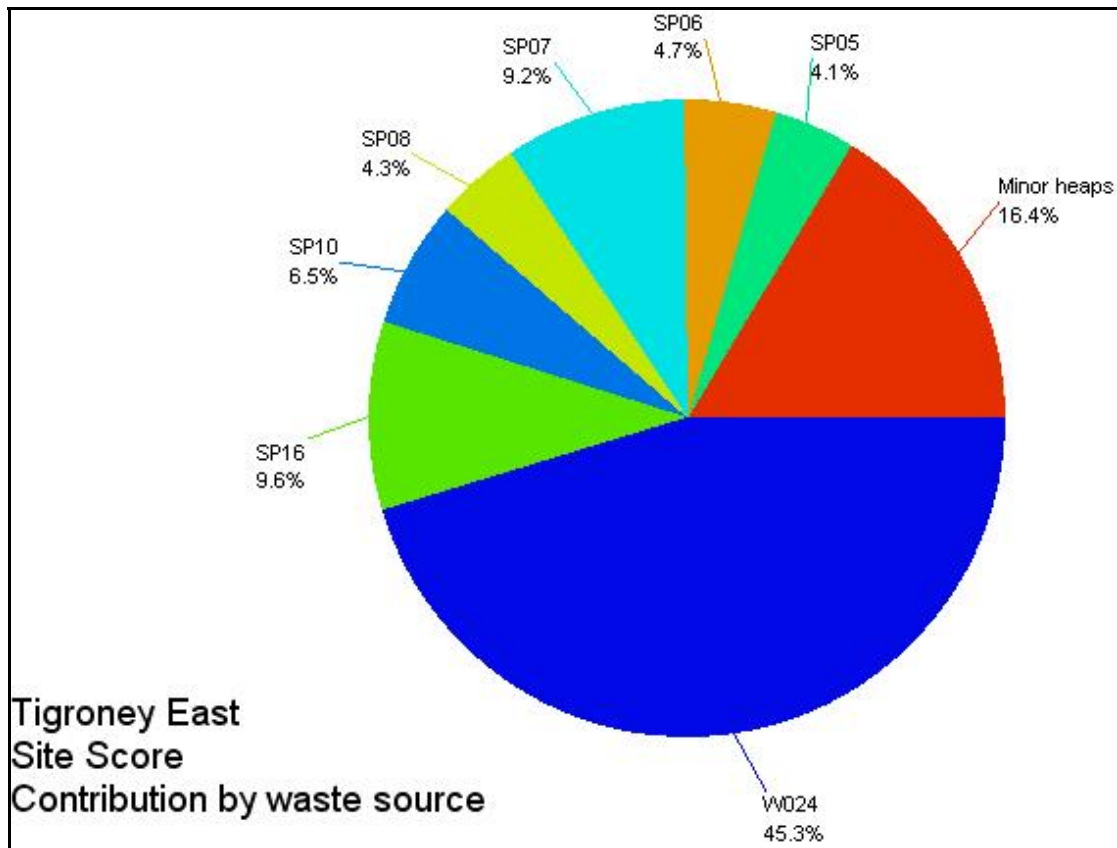
Waste	SP05	SP06	SP07	SP08	SP10
<b>1. Hazard Score</b>	<b>26</b>	<b>38</b>	<b>75</b>	<b>40</b>	<b>46</b>
<b>2. Pathway Score</b>					
<i>Groundwater</i>	5.37	9.23	16.65	9.67	11.19
<i>Surface Water</i>	9.05	2.90	5.59	3.09	3.50
<i>Air</i>	0.06	0.31	0.75	0.20	0.61
<i>Direct Contact</i>	0.71	4.65	10.74	2.79	8.40
<i>Direct Contact (livestock)</i>					
<b>3. Site Score</b>	<b>15</b>	<b>17</b>	<b>34</b>	<b>16</b>	<b>24</b>

Waste	SP11	SP12a	SP12b	SP12c	SP12d
<b>1. Hazard Score</b>	<b>14</b>	<b>15</b>	<b>13</b>	<b>12</b>	<b>12</b>
<b>2. Pathway Score</b>					
<i>Groundwater</i>	3.87	4.03	2.71	2.81	2.93
<i>Surface Water</i>	1.12	2.59	2.27	2.19	2.19
<i>Air</i>	0.01	0.06	0.00	0.00	0.02
<i>Direct Contact</i>	0.08	0.31	0.08	0.01	0.08
<i>Direct Contact (livestock)</i>					
<b>3. Site Score</b>	<b>5</b>	<b>7</b>	<b>5</b>	<b>5</b>	<b>5</b>

Waste	SP13	SP14	SP15	SP16	SP17
<b>1. Hazard Score</b>	<b>17</b>	<b>12</b>	<b>12</b>	<b>81</b>	<b>20</b>
<b>2. Pathway Score</b>					
<i>Groundwater</i>	3.41	2.81	2.81	20.47	5.14
<i>Surface Water</i>	3.23	0.94	0.94	6.08	1.55
<i>Air</i>	0.00	0.00	0.00	0.53	0.01
<i>Direct Contact</i>	0.79	0.01	0.03	7.66	0.14
<i>Direct Contact (livestock)</i>					
<b>3. Site Score</b>	<b>7</b>	<b>4</b>	<b>4</b>	<b>35</b>	<b>7</b>

Waste	SP18	SP19	W024	Totals
<b>1. Hazard Score</b>	<b>18</b>	<b>18</b>	<b>280</b>	749
<b>2. Pathway Score</b>				
<i>Groundwater</i>	4.10	4.28	43.05	154.50
<i>Surface Water</i>	1.40	1.40	122.63	172.65
<i>Air</i>	0.00	0.00	0.00	2.57
<i>Direct Contact</i>	0.01	0.10	0.00	36.57
<i>Direct Contact (livestock)</i>				
<b>3. Site Score</b>	<b>6</b>	<b>6</b>	<b>166</b>	<b>366</b>

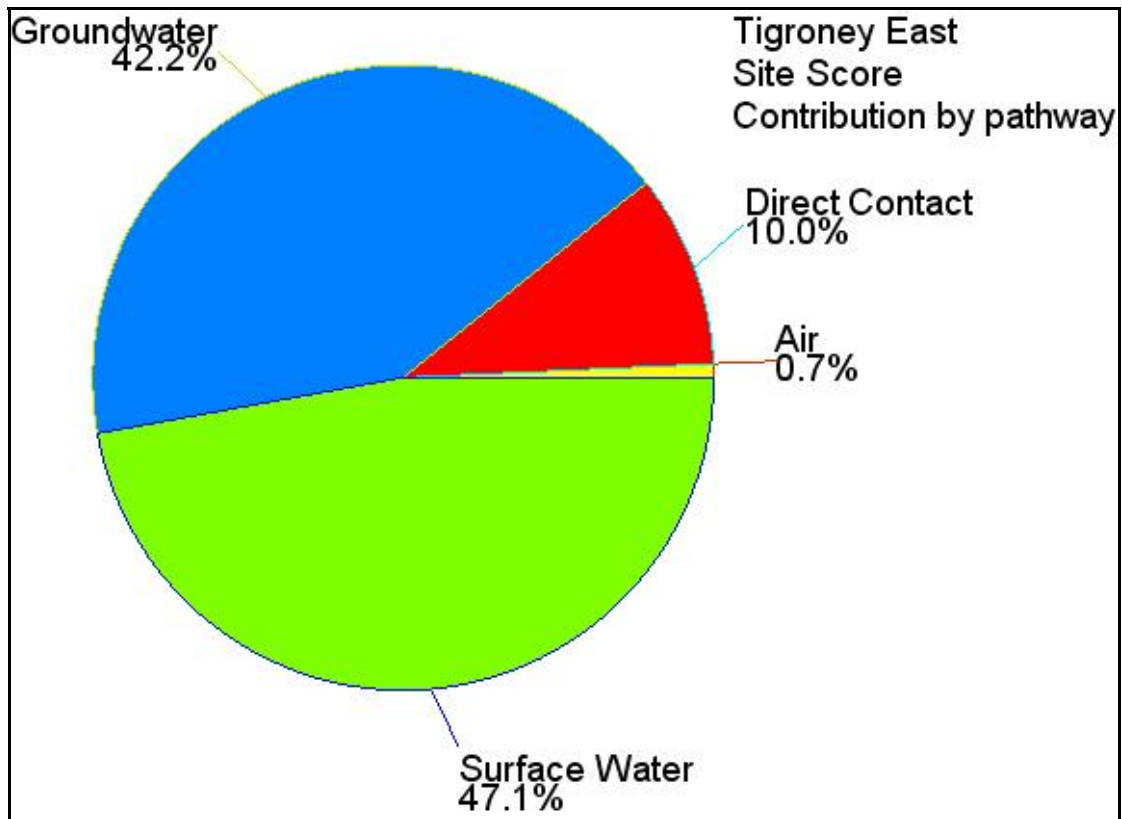
The total site score for Tigrone East is 366 (Table 4). Of this, the solid waste accounts for 55%. The Cronebane Shallow adit discharge (W024) contributes the remaining 45% of the score (Fig. 5). Although the volume of water discharged by the Cronebane Shallow adit is not particularly high (< 1 l/s), it is very enriched in metals. Solid waste heaps in Tigrone East are for the most part small-scale and their scores reflect this. One heap, SP16, is particularly rich in Pb and, as a consequence, despite its relatively small size (Table 1), it has the highest individual score of any waste heap in Tigrone East.



**Fig. 5 Contribution of individual waste sources to Tigroney East Site Score**

The contribution of individual pathways to the Tigroney East Site Score is illustrated in Fig. 6. Pathways are the routes by which receptors are exposed to the hazard. The dominant role of the Cronebane Shallow adit in the scoring gives extra weight to the surface water pathway which, as a consequence, accounts for 47% of the score as opposed to 42% for the groundwater pathway. In contrast, in Cronebane and Connary, the ratio of groundwater to surface water pathway score is around 2:1. The direct contact score is similar to that at Connary and much higher than at Cronebane, reflecting a lower volume:area ratio for the spoil heaps. Although few waste heaps in Tigroney East are vegetated to any significant extent, the air pathway score is typically low.





**Fig. 6 Contribution of individual pathways to Tigroney East Site Score**

## 6. Geochemical overview and conclusions

Tigroney East contains numerous spoil heaps. Not all of them are well characterized chemically but, in general, concentrations of Pb, As and Zn are similar or a little lower than those elsewhere on the Avoca site while Cu concentrations are higher. The latter reflects a cluster of high Cu values in the vicinity of Baronet's engine house where ore was raised in the 19<sup>th</sup> century. One part of one heap (SP16) is enriched in Pb (>10%). Caved areas on the site have been filled with what appears to be relatively low-grade waste. Tigroney East is a significant source of ARD that is generated by run-off of rainwater during periods of heavy rain. This run-off is channelled into a drain at the southwestern end of the site which eventually meets the discharge from the Deep adit before entering the Avoca River.

The discharge from the Cronebane Shallow adit is very acidic and very metal-rich. However, the flow is small and drains back into the ground in the area of caving. A much larger flow within the open pit drains straight into the underground workings. Its main impact has been the creation of a low-pH, metal-rich pond in the base of the open pit.

## **References**

CDM (2008) Feasibility Study for management and remediation of the Avoca Mining site. Prepared for the Geological Survey of Ireland. CDM, USA.

Gallagher, V. and O'Connor, P.J. (1997) Characterization of the Avoca mine site: geology, mining features, history and soil contamination study. Geological Survey of Ireland Technical Report MS97/1.