SECTION 4

- GSI Characterisation of Avoca Mines Extract 1997 with accompanying maps
- Pre-Landfill "Blue Print" Drawing 1988
- General Design Description of Proposed Landfill 1988

around the time that Wood adit was driven, in the first half of the 19th century, in order to take advantage of the discharge from it.

4..3 WEST AVOCA SURFACE MINING FEATURES

Most of the modern mining at Avoca took place in the West Avoca mine. This was mainly underground mining but one open pit was also operated. Excavation of this pit together with the construction and subsequent removal of the mill and extensive workshops have significantly reduced the number of surface mine features on the site. The West Avoca site covers an area of approximately 286,000 m^2. There is a relatively large number of buildings dating from the modern mining period scattered in and around the mine site. Most of those in the areas surrounding the site were mine workers' accommodation and are now private dwellings. Spoil heaps cover 29% of the mine area (81,690 m^2) and the open pits a further 12% (33,181 m^2). The remaining 59% of the site comprises roads, paths, heathland and forested areas and the sites of the mill and other buildings, now landscaped and revegetated.

4.3.1 Spoil heaps

Spoil heaps in West Avoca, like those in East Avoca, are products of both old and modern mining activities. The most prominent heaps, including SP33 above the modern mine portal, SP34a, SP34b and SP35 on Ballymurtagh hill and SP39 running along beside the main road below Bell Rock, were all produced in the 19th century as a result of surface ore dressing (Fig. 4.14). Some, notably SP35 and SP34a, show stratification that is a feature of cobbings. Some of these older heaps are extensively colonized by local plant species, notably heather, gorse, pine and birch.

In the modern underground mine, waste rock was backfilled underground. However, North Lode open pit, excavated in the mid-19th century, was employed by AML as an emergency tailings pond. It is now filled by tailings and covered with a surface layer of spoil (SP 34). Excavation of the Pond Lode open pit in the 1970s did not give rise to waste heaps on the site: all material not left in the pit itself was passed through the mill.

Spoil heaps in West Avoca were mapped in the same manner as those in East Avoca. Descriptions are given in Appendix 4.1. Areas of heaps were derived from AutoCAD and the volumes of most were calculated using the area and estimates of height based either on contour data or visual inspection. In the case of SP39, sections derived from surveys by P. Behan Engineers were used to estimate the volume, as described for East Avoca heaps (section 4.2.1). The volume of SP34, the tailings filling the old open pit, was assumed to be the same as that of the old North Lode open pit (section 4.3.2). Table 4.2 summarizes the data for West Avoca spoil heaps.

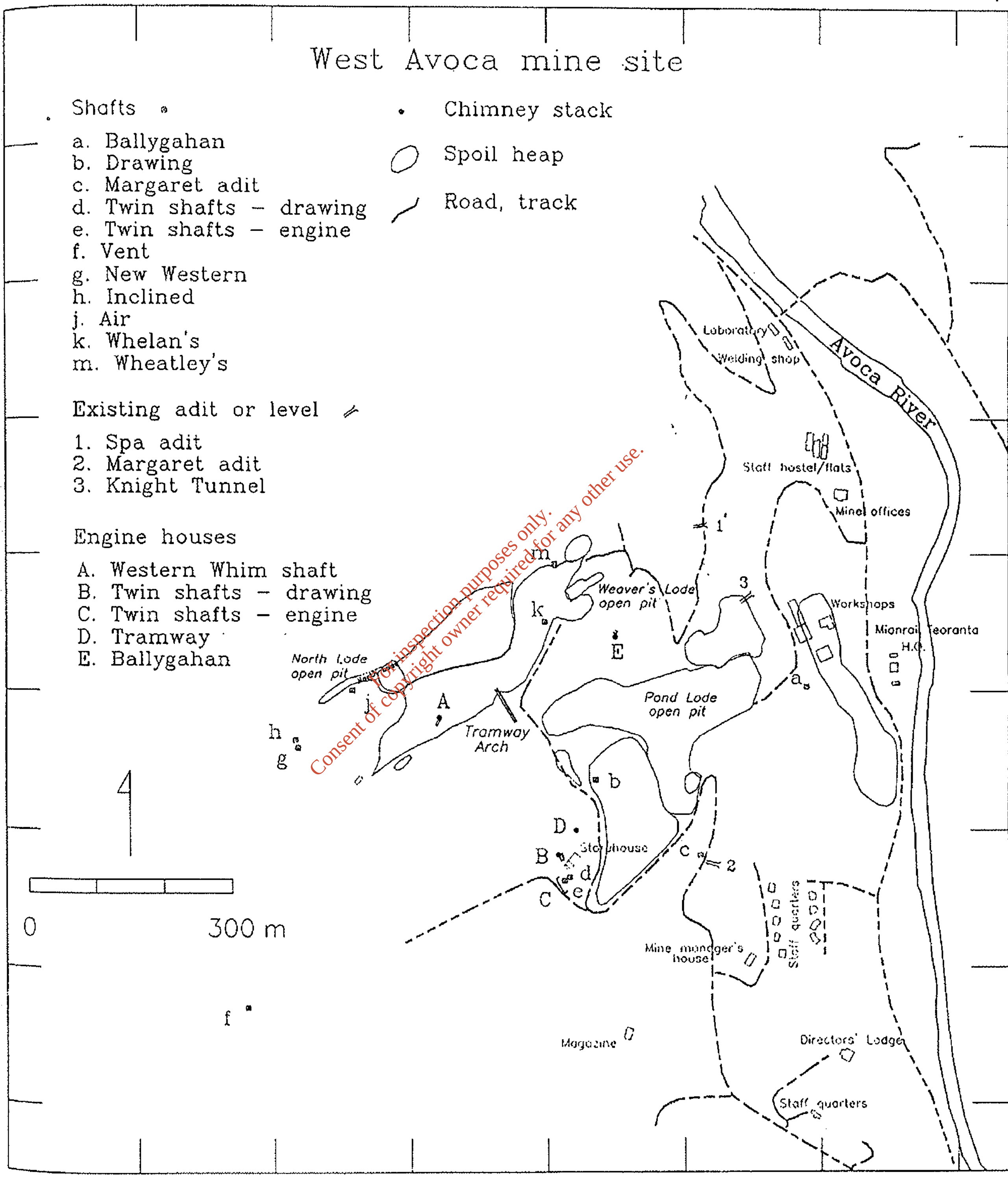


Figure 4.14 West Avoca mine site, main features

Table 4.2 West Avoca spoil heaps: areas, volumes and plant colonization

Spoil heap	Area, m^2	Volume, m^3	Colonized area, m^2	% of heap area colonized
SP33	7253	7253*	1135	15.6
SP34	14304	233220	5112	35.7
SP34a	1034	20680	0	0
SP34b	25028	25028*	5900	23.5
SP35	242	4840	0	0
SP36	808	3232	0	0
SP37	17902	17902*	2607	14.5
SP38	526	1052	0	0
SP39	14593	109071**	3006	20.5

*Thickness unknown: 1 m assumed. **Based on survey by P. Behan & Co.

4.3.2 Open pits

West Avoca contains the remains of North Lode open pit and Weaver's Lode (or south North Lode) open pit, both worked in the 19th century, as well as Pond Lode open pit, excavated by Avoca Mines Ltd. between 1973 and 1979 (Fig. 4.14). Only the small Weaver's Lode open pit remains extant: North Lode open pit was used by Avoca Mines Ltd. as an emergency tailings pond and is almost completely filled; Pond Lode open pit is currently used by Wicklow County Council as a domestic refuse disposal site and is expected to be filled by 1999.

1. North Lode open pit

North Lode open pit was mined by the Wicklow Copper Mining Company in the 1850s. When finished it had a length of about 300 m, a maximum width of 30 m and an average depth of 30 m. The area of 7,774 m^2 implies a volume of 233,220 m^3 if the walls of the pit are taken as vertical. It was, for a time, the largest open pit in the world (P.McArdle, pers. comm.). A contemporary account (Anon. 1856) catches well the wonder engendered by the North Lode and its workings: "I have never seen anything equal to [the Great North Lode]. On the surface of the hill ..... appears a large bed of gossan, comprised of brown hematite ore, which reaches the enormous width of 100 feet. This gossan ..... has been worked as a quarry at the surface to this enormous width. It is a most striking sight to stand upon the edge of this great excavation and mark its enormous size which certainly shakes all of our preconceived notions about lodes and mineral veins." The gossan, itself a valuable ore containing 52 % iron, formed a surpergene cap to massive pyrite ore which in the 1850s was the main export from Avoca. The pyrite was mined mainly from underground workings that remain, apparently mostly intact, below the open pit.

Today, only the uppermost sections of the pit walls at the southwestern end of the pit remain as evidence of the pit's existence. These walls define an area of approximately 2,529 m^2. The remainder of the pit is filled by tailings and fine spoil. The surface is currently the site of the Life project revegetation trials conducted by Wicklow County Council. There is also some extensive natural colonization of spoil by heather and gorse, especially at the southwestern end in the area sheltered by the exposed pit walls.

2. Weaver's Lode open pit

This small pit has a length of 60 m, a maximum width of 10-15 m and a maximum depth of 10 m. Little is known about it or about the lode itself. It is not marked on Smyth's 1853 map. Mianrai Teoranta described this as "North Lode, south" and evidently it was excavated in the 1850s contemporaneously with North Lode open pit. Barnes (1864) referred to the lode as a sort of reserve, with full-scale mining of it awaiting an upturn in demand. The pit is underlain by limited underground workings, previously accessed by the Spa adit. Mianrai Teoranta described the pit on their 1951 map as the result of "caving, iron ore and ochre workings."

The pit is of interest today because it contains good footwall and hangingwall exposures of ore host rocks. The floor of the pit is obscured by debris and spoil and no has been observed during this study.

3. Pond Lode open pit

The Pond Lode open pit has been referred to in recent years as Ballymurtagh open pit but this name could equally be applied to the North Lode or Weaver's Lode open pits. Its original name is therefore preferred here. It was excavated between 1973 and 1979 by Avoca Mines Ltd. on the surface extension of the Pond Lode and a total of 1,077,730 tonnes of ore grading 0.6% copper was produced. Prior to this, the area had suffered extensive caving as a result of the collapse of underground workings precipitated by removal of pillars by SPCM in 1961-62. The open pit is approximately 320 m long and varies in width from 50 to 200 m. In 1996 its surface area was 29,779 m^2. It is currently being infilled with domestic refuse, a process scheduled to be completed by 1999. Although a number of features of geological interest remained exposed in 1996, these will be covered in due course.

4.3.3 Adits and levels

Many of the underground workings in West Avoca in the 19th century were below the level of the river and access was generally by shaft rather than adit. This, together with the effects of modern mining, means that few adits are exposed today on the site.

1. Road adit (32 m O.D.)

This adit was driven in the 19th century to Ballygahan shaft and served as a drain for water pumped up the shaft from the deep mine workings. In 1864, a 50" cylinder pumping engine was used to raise water some 600 feet (180 m) from the bottom of the mine and discharge it through this adit. An average of 10,000 gallons (45,500 litres) were raised per hour (Barnes 1864).

The adit is located beside the main Avoca - Rathdrum road opposite Wicklow County Council's yard (Fig. 4.14). It was exposed here until the 1980s but is now covered by coarse mine spoil. It is the main point of discharge for mine water in West Avoca and was used by both SPCM and AML. The discharge is currently channelled into a pipe and thence to the Avoca river.

2. Spa adit (114 m O.D.)

The Spa adit was driven in the 1850s by WCMC to provide access to mine workings on the south branch of the North Lode (Weaver's Lode) (Fig. 4.14). It is located immediately east of the road between the North Lode area and White Bridge. The adit is bricked up but a pipe allows drainage of mine water. According to one report (Mining Services 1963), the adit is partly collapsed. It originally had a length of about 300 m and it appears to be the only discharge pathway for mine water in the area of Weaver's Lode. The North Lode workings are directly linked to and drain into the main West Avoca underground mine workings.

3. Margaret adit (84 m O.D.)

This adit was begun in the 18th century by HMC with a view to discovering further copper lodes north of the main lodes in West Avoca. It was abandoned before anything of interest was intersected. WCMC later (1852) extended the adit, proving the South Lode in depth, discovering the Pond Lode and Weaver's Lode and proving the North Lode in depth. The adit is the only significant cross-cutting adit in West Avoca. It was still accessible via a trapdoor in the garden of a private house when the mines closed in 1982 (Fig. 4.14). It is now sealed by a concrete cap.

4. Knight Tunnel (65 m O.D.)

The Knight Tunnel was the main decline or access tunnel to the underground mine in modern times. Shafts were not used in modern times except for services. The tunnel measured 5 x 5 m at its portal. Trackless vehicles, including load-haul-dump and drilling vehicles, were driven along it and could enter all parts of the underground workings. The opening of the Knight Tunnel thus signalled the start of the modern mining era in Avoca when large volumes of ore could be transported rapidly from the mining face. In the deeper levels, the ore was carried to an underground crusher and thence to the surface mill by a conveyor. In the upper levels of the mine, trackless vehicles were used to transport ore. SPCM began constructing the decline in 1955 and it reached the 1670 level. AML extended it in the early 1970s to the 2000 level. The tunnel has a decline of 12° and descends vertically some 350 m by reversing direction at six points.

The Knight Tunnel was sealed by a concrete plug after the mine closed in 1982. The new road constructed by WCC to provide access to the landfill site in Pond Lode open pit largely obscured what remains of the portal but the top of it is still visible.

5. Ballygahan Deep Adit (30 m O.D.)

This adit was linked to Ballygahan old engine shaft, formerly on the site of Pond Lode open pit, and drained to the Avoca river. A narrow pipe in the river embankment (Fig. 4.14, MAP 5) now appears to carry discharge from this adit. No other trace of it has been found. Argall (1880) and Smyth (1853) illustrate the adit. It runs directly under the floor of Pond Lode open pit.

4.3.4 Shafts

Mianrai Teoranta's 1951 map of the mine workings in West Avoca shows numerous shafts linking adits and levels to the surface (Fig. 4.15). Many of these have since disappeared, removed during open pit excavation or covered during other surface activities. Most of those still visible on the surface are part of the North Lode workings which remain largely intact.

1. Vent shaft

This is the only shaft constructed during the period of modern mining between 1955 and 1982. It was begun by AML in April 1971 at the southwestern end of the mine workings, linking the 1670 level with the surface and foul air was exhausted through it. Fans located in this shaft and in the Twin shafts drew 280,000 cubic feet (4,375 m^3) per minute of fresh air through the mine workings via the Knight tunnel and Ballygahan shaft.

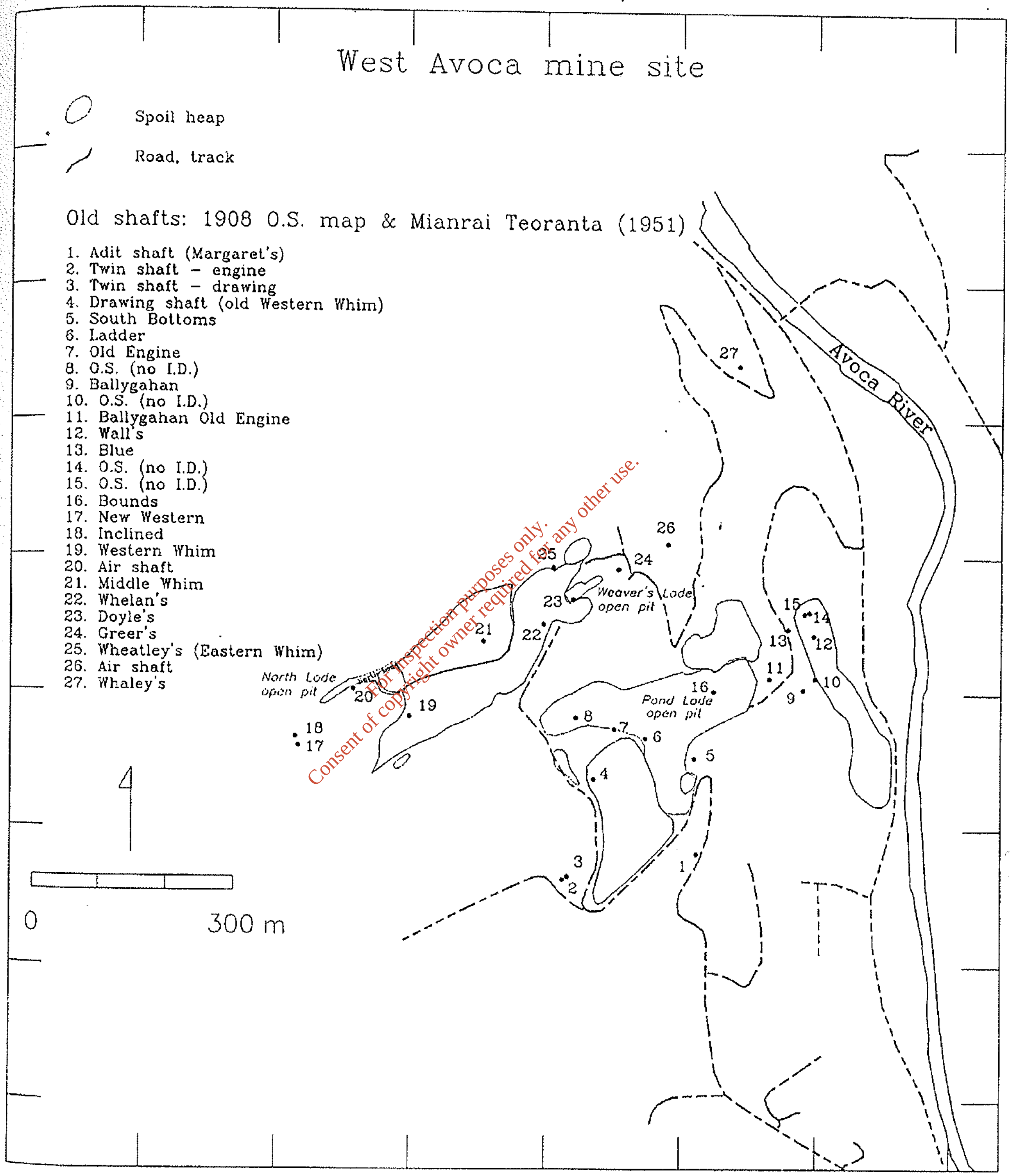


Figure 4.15 West Avoca, shafts mapped by Mianrai Teoranta, 1951

The shaft is located in pasture west of the farm buildings to the southwest of the mine site (Fig. 4.14). It is easily recognized by its 2 m high cylindrical concrete cap. A small vent in the cap allows measurement of water level in the mine workings. The shaft runs vertically from the surface (138 m O.D.) to the 1040 level (-12 m O.D.) and then inclines to the 1670 level (-201 m O.D.).

2. Twin shafts

WCMC began work sinking these engine shafts side by side in the early 1850s (Smyth 1853) as part of the westward extension of the mine. By 1864, they had reached their final depth of about 300 m below the surface and formed "an efficient means of communication, drainage and discharge" (Barnes 1864). They were "projected at a period when the prospects in copper were most abundant and showing a large breadth going west and to replace the old underlay shafts which had become unequal to the discharge of the increasing quantity of ore and for the fixing of new and enlarged pitwork" (Barnes 1864). The shafts were used for pumping water (Engine shaft) and raising ore (Drawing shaft). According to Barnes (1864), a whim engine was used on the drawing shaft. In the modern era, the Twin shafts have been used only for ventilation purposes and as an escape way.

Each shaft consists of a bare single compartment, 7' x 7' (2.1 x 2.1 m) in size (Mining Services 1963). When originally constructed, the shafts were vertical over the first 221 m to a depth of -90 m O.D. and then inclined to -170 m O.D. They connect with the Margaret adit and with the modern 995, 1121 and 1300 levels. Today, the shafts have concrete caps. The remains of hoisting wheel supports are visible nearby.

3. Margaret adit shaft

This short shaft (a few metres deep at most) linked Margaret adit to the surface, about 30 m from the adit entrance. It was presumably a ventilation shaft. Today, the shaft is collapsed and is marked by a conical pit beside the Red Road.

4. Drawing shaft (Western Whim)

According to Smyth's map (1853) and the Mianrai Teoranta map (1951), the Drawing shaft extended vertically from 129 m O.D. to the 935 level (19.5 m O.D.) and then inclined to the 1550 level (-165 m O.D.). It dates from at least the mid-19th century when a whim engine "of small dimensions" (Smyth 1853) was used to raise ore along it and it was called the Western Whim shaft. It is marked on the 1908 O.S. maps beside an engine house and stack, neither of which remain today. Caving during 1958-62 following SPCM mining led to the collapse of the shaft from a point 50 m below the surface down to the 935 level. Prior to this, the shaft had been used for supplying fresh air to the mine using downcast fans installed on the 935 level (Mining Services 1963).

The Drawing shaft is today within the fenced area on ground above the southwestern wall of Pond Lode open pit (Fig. 4.14). It is capped by concrete that has encouraged a thick growth of vegetation around it.

4. Ballygahan shaft

Ballygahan shaft dates from at least the first half of the 19th century and was the main shaft in the old Ballygahan mine, used both for pumping water and for hoisting ore (Fig. 4.14). Power was supplied via an overshot water wheel of "50 feet diameter and 30 inches breast" (Smyth 1853). In the 1940s, Mianrai Teoranta rehabilitated the shaft and deepened it to -230 m O.D., 290 m below the surface, driving a new level, the 1670 level (-201 m O.D.), 750 m to the southwest (Mining Services 1963). Mianrai Teoranta, SPCM and AML used this shaft as the main discharge route for mine water. Reservoirs were located at the 1670 and 70 fm levels. Mianrai Teoranta pumped water from the 1670 level to the 70 fm level and from there to the river via the Road adit. SPCM installed a KSB pump to pump water directly to the Road adit from the 1670 level. AML followed this procedure. Electrical cables and water lines were also brought into the mine via the shaft.

Ballygahan shaft is a small, four-compartment shaft, timbered with 8" x 8" (20 x 20 cm) sets. Two of the compartments, each 4' 1" x 3' 10" (1.23 m x 1.15 m), were used for hoisting ore (Mining Services 1963).

5. New Western shaft

This vertical shaft was begun around 1860 (Barnes 1861) and extended to 141m O.D., 48 m below the surface, where it connected with the western end of the 30 fm level. It was sunk at the western end of the North Lode, providing a link to the levels being driven westwards along the lode. This shaft was open along its length in 1951 (Mianrai Teoranta). It is now capped and surrounded by a fence in an area overgrown by gorse and heather (Fig. 4.14).

6. Inclined shaft

This short shaft is located beside the New Western shaft within the same fenced area and was sunk around the same time. The North Lode mine was developed in both an easterly and westerly direction simultaneously and the Inclined shaft and the New Western shaft were probably the last ones to be sunk. The Inclined shaft is very short and does not connect to any North Lode levels (Mianrai Teoranta 1951). A note on Mianrai Teoranta's 1951 map/section suggests that is was used for working ochre deposits.

7. Air shaft

This is a short vertical shaft. It is not shown on the Mianrai Teoranta map and its depth is unknown. It is surrounded by a fence. Some steel bars are set across the top but the shaft is effectively open.

8. Whelan's shaft

This is the only remaining shaft on Weaver's lode (Fig. 4.14). This lode was regarded as a reserve by WCMC and was not opened beyond the 30 fm level (54 m below surface). Whelan's shaft was sunk vertically to 138 m O.D., 45 m below the surface, and then inclined to 114 m O.D. It was linked to the Spa adit. In 1951, the shaft was apparently open along its length (Mianrai Teoranta 1951). Today it is capped and fenced off.

9. Wheatley's shaft

This was also known as the Eastern Whim shaft. In 1951 it was open along its length (Mianrai Teoranta 1951). It extends vertically 48 m below the surface to the 45 fm level (120 m O.D.) and then inclines to the 80 fm level (63 m O.D.), intersecting the 60 fm level (95 m O.D.). Little information is available about its development. It is now capped and fenced off (Fig. 4.14).

4.3.5 Engine houses and stacks

1. Twin Shafts engine houses

Two engine houses are located nearby and were apparently employed on the Twin Shafts (Fig. 4.14). The walls and chimney stack of the northernmost one, located on the Drawing shaft, lie behind the ruins of Mianrai Teoranta's storage buildings and are largely intact though covered in ivy. The southernmost one, beside the Engine shaft, is immediately beside the farm road and is now in ruins with only the base of parts of three walls discernible. Both of these buildings presumably date from the early 1860s when sinking of the Twin Shafts was completed. As noted by Coy (1996), the intact chimney stack is lower than other stacks at Avoca. The Drawing shaft was worked by a whim engine which raised the ore from underground; the engine employed on the Engine shaft was used for pumping out water.

2. Tramway Engine house stack

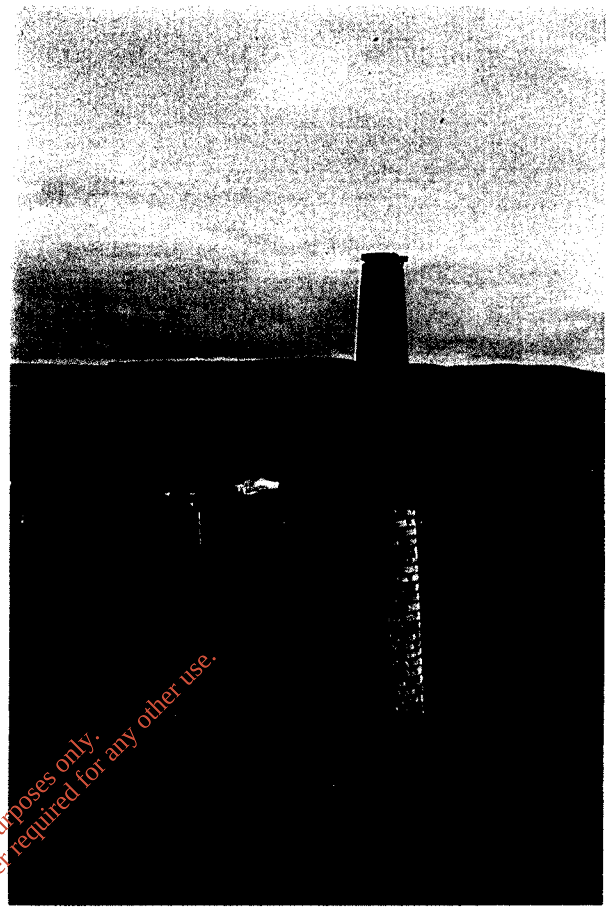
This ivy-covered stack (Fig. 4.14) stands immediately beside the path of the old tramway (below, 4.3.7). The engine was used to haul ore wagons. The engine house is now demolished.

3. Ballygahan Engine house

This house consists of an intact chimney stack and low ruined walls on the overgrown ground above the northern wall of Pond Lode open pit (Fig. 4.14, 4.16a). It has been referred to as "Ballygahan" engine house (Merrigan, pers. comm.) but no reference has been found to it in the literature and it is not marked on any pre-20th century maps seen during this study. No mine workings are known to lie below it or even close to it. A narrow channel immediately east of the house may be a counter balance pit or flat rods channel. It appears to extend southwards. If it is a flat rods channel, then it must originally have extended to a shaft. A straight line extending 70 - 80 m south along the direction defined by the channel passes within 10 m of a shaft marked on the 1908 O.S. map but absent from Mianrai Teoranta's 1951 map and from Smyth's 1853 map. The identity of this shaft is unknown. It does not appear to have been an engine shaft. The Ballymurtagh Old Engine shaft, the only known engine shaft in the vicinity, was further west. If the line of the channel is extended 135 m northwards it passes within 6 m of Wheatley's shaft. The closest *existing* shaft is Whelan's shaft (100 m distant) on Weaver's lode but this lies oblique to the line of the channel. Of these, Wheatley's shaft is the most likely, given its depth, to have been operated using an engine.

4. Western Whim engine house

The base of a stack remains south of the North Lode open pit and west of the Tramway Arch (Fig. 4.14). The old Western Whim shaft was situated 40 m west of this stack. Two adits, one an access adit and one water discharge, were connected to the shaft in 1951 (Mianrai Teoranta 1951). According to Barnes (1864), the underground works of the North mine were initially drained along Margaret adit and finally, after the 56 fm crosscut was completed, to the main underground workings of the South mine: "It is no small advantage to the mine that we have obviated the necessity of additional pumping machinery by the deep sinking and crosscut connecting the North and South mine, a heavy piece of work which has taken many years to complete, the miners having to be supplied with air part of the time, driven through' pipes by machinery. The North mine has thus been laid dry to a depth of 132 fathoms [792 feet or 239 m] perpendicular to the surface.". Thus, engines were not used for pumping water from the underground workings and it must be assumed that this engine house was constructed for raising ore. The reason for the reference on Mianrai Teoranta's 1951 map to discharge from an adit is unclear.



(a) Ballygahan engine house and stack, West Avoca, looking SE.

(b) Tramway arch, West Avoca, linking Hodgson's tramway and North Lode open pit. Viewed from west.

FIGURE 4.16

4.3.6 Other mine buildings

1. Pre-20th century

The ruins of one small building can be seen directly south of the North Lode Air shaft. No specific reference to it has been found in the literature or on any map.

2. Mianrai Teoranta 1941-1955

A number of buildings constructed and/or used by Mianrai Teoranta remain. The most prominent building on the site is the concrete shell of **storehouses** located beside the Twin Shafts. Wicklow County Council's yard, east of the main road 200 m south of the entrance to the West Avoca site, is the site of **Mianrai Teoranta's headquarters** (Fig. 4.14). The stone buildings here appear to date at least from this time: they are not marked on the 1908 O.S. maps.

3. Saint Patrick's Copper Mines Ltd.

A large number of buildings used and in many cases purpose built by SPCM staff remain on and around the West Avoca mine site. On site, the building north of the site entrance was built by SPCM as its **main office** and was later used by AML for the same purpose (Fig. 4.14). It is now being renovated for use as a miners' museum. Behind this building are the old **staff hostels** (Fig. 4.14). AML later converted these to apartments, also for staff accommodation. The remaining buildings are outside the site. Across the road from White Bridge are two buildings: the one to the south was used as a **garage** and the other as a **laboratory** for sample analyses by SPCM. AML used the first building as a **welding shop.** Both buildings are now privately owned and in use as workshops/dwellings. South of Bell Rock and east of the Red Road, there are twelve houses used as **staff quarters**. They include a **Directors' Lodge** and **Mine Manager's house**. Most of this appear to have been built by the company and were subsequently used for the same purpose by AML. All are now in private hands. West of the Red Road is the building used as a **magazine** by SPCM for storing explosives.

4. Avoca Mines Ltd.

As noted above, AML utilized many of the buildings constructed by SPCM, including the now dismantled mine buildings such as the mill, as well as housing stock. Apart from these buildings, the only remains specific to AML are the concrete foundations of workshops that are visible east of the entrance road to the West Avoca landfill site.

4.3.7 Hodgson's Tramway and Tramway Arch

This tramway was built to haul ore from West Avoca to Arklow harbour. Previously, ore had always been carted to Arklow by local people who agreed a price per ton of ore and supplied their own horse and cart. But there had been recurrent difficulties, with transport periodically in short supply, for example at harvest time when all available carts were needed in the fields (Cowman 1994). Henry Hodgson, proprietor of Ballygahan mine and director of WCMC which operated Ballymurtagh mine, decided to construct a tramway to haul ore to Arklow. At this time, the national rail network consisted of a short line from Dublin to Kingstown (Dun Laoghaire). The tramway was completed in 1846, a fortuitous date since the beginning of the Great Famine reduced sharply the availability of drivers and transport (Barnes 1864): "Before 1846, and the famine period, the neighbourhood supplied horses and carts in abundance. Since that date the ores have been carried to Arklow by tramway." Ore from East Avoca continued to be transported by horse and cart.

The tramway probably began originally at the Tramway Engine house and followed a straight line southeast before running along what part of what is now the Red Road. Later, as the North mine was being developed, the tramway was extended to the north over an arch to the North Lode open pit. The Tramway Arch (Fig. 4.16b) is one of the most striking architectural features preserved at Avoca. Between 1857 and 1859, the Avoca - Dublin railway was joined with Hodgson's Avoca - Arklow railway.

4.3.8 Water drainage and discharge

The West Avoca mine is drained today in much the same way as it was in the 19th century, i.e. via Ballygahan shaft, although today the water drains along the Road adit whereas then it was pumped out with power supplied from a water wheel. In the 1940s and 1950s Mianrai Teoranta drained water from the Twin Shafts along the now-disappeared 22 fm adit and subsequently to the Avoca River via the Red Road stream. They also constructed a pipeline to carry discharge to the river. This is visible close to the Ballygahan shaft and can be traced south along the side of the spoil heap SP39 until in turns to drain below the road and into the river at the site of the Ballymurtagh weir. At this time, water levels in parts of the mine would have been higher than they are today both because the workings were much shallower and less extensive and because various dams were constructed to block off different sections from one another. This pipeline appears to have been built to draw off water from the upper levels of the mine. Subsequently, SPCM revised the drainage system as described above (section 4.3.4) and the mine has since been drained mainly via the Road adit.

4.4 UNDERGROUND MINE WORKINGS

For most of its history, Avoca has been operated as a number of underground mines. There is a 27 km long network of adits and levels in East Avoca; the aggregate length of shafts, prior to open pit excavation, was 3.5 km. In West Avoca, there are some 15-20 km of levels and more than 1 km of shafts. There also remain huge volumes of stopes, partly backfilled, some collapsed. The deeper levels of the mines, below c. 30 m O.D. or the level of the Avoca river, are flooded. The East Avoca workings were mainly driven in the 18th and 19th centuries. Only the 850 adit, built by SPCM in 1958-1962, post-dates this. Excavation of East Avoca open pit and, especially, Cronebane open pit removed the upper levels of the workings although most remain. Their condition is unknown but probably poor. They were last completely mapped in the late 1940s and early 1950s by Mianrai Teoranta geologists, who produced maps and sections of both East and West Avoca underground workings. Extensive underground development by SPCM and AML, excavation of the Pond Lode open pit and serious caving in the upper levels have brought many changes to the West Avoca underground workings since the 1950s. The exception is the North Lode mine, untouched since the 19th century, where the Mianrai Teoranta map still appears valid. Plans of the individual levels driven by AML and, in the case of some of the upper levels, by SPCM form the basis for the underground map of the modern West Avoca mine.

Two 3-D digital maps of underground mine workings have been compiled, one of East Avoca (Map 4) and one of West Avoca (Map 5). In both cases, the emphasis has been placed on drawing the adits, levels and shafts in order to convey the spatial extent and complexity of mine workings. For East Avoca, no stopes have been drawn. Although stopes are shown in section on the Mianrai Teoranta compilation, no plans are available for them so they cannot be drawn accurately in a 3-D map. Stopes have been drawn in the West Avoca map since the modern mine plans generally contain stopes outlines which can be linked on successive levels. However, not all plans show stopes and in places stopes are drawn in a somewhat schematic way. Plans of lodes appear on many West Avoca mine plans so Map 5 contains reconstructions of the Pond Lode and South Lode. Gaps in the data mean that these are also schematic to some extent. Appendices 4.2 and 4.3 contain a listings of all levels, adits and shafts drawn in Maps 4 and 5 and a list of data sources.

Adits and levels have been given a standard width/height, usually 2 or 3 m, except where exact information is available. For example, the Knight Tunnel is known to have measured 5 x 5 m. Shafts have all been drawn with 4 x 4 m horizontal dimensions, partly for convenience. In many cases, they exceed known dimensions.

The maps were digitized in AutoCAD. 3-D drawing techniques were employed to digitize vertical and inclined shafts and to position the adits and levels at different topographic elevations. The AutoCAD drawing can be viewed from any perspective and overlaid in 2-D on the topographic map. Unfortunately, they are not "solid", i.e. they lack any depiction of ground and the various features in it appear simply as a series of connected lines. In 3-D, they overlap in space such that drawing elements which should be hidden from the viewer by other elements in front them instead can still be seen. AutoCAD allows some hiding of these lines, so reducing the confusion. Nevertheless, the lack of any background terrain element in the drawing makes it essentially a technical drawing, suitable mainly for scientific/engineering purposes. For display purposes, especially in the context of the Life project, a more realistic version was felt to be necessary.

The technique of Ray Tracing was used to create a "solid" 3-D image of the underground workings (Fig. 4.17 and 4.18). Using information about the viewer's perspective and the position of the drawing elements, levels, shafts, etc., in space, ray tracing involves rendering an image based on mathematical modelling of the interaction of light rays and the objects of interest. The images generated by ray tracing software make use of "primitive" geometrical objects such as cylinders, spheres, etc. Grouping these together can produce a complex 3-D image. For example, in the image of the underground workings at Avoca, the horizontal levels are rendered as cylinders (Fig. 4.17 and 4.18). The software package used for the Avoca images is *Rayshade* and the images were output at large screen resolution (1920 x 1440) for subsequent reproduction on 35 mm transparency film. The ray tracing modelling was carried out for GSI by Dr. K. Russ, Camborne School of Mines, Cornwall, England.

4.5 ENVIRONMENTAL IMPACTS

4.5.1 Introduction

The two major environmental impacts observed at Avoca mines are 1) the pollution of the Avoca river by AMD and 2) physical alteration of the landscape by mining activity. The contamination of soil in areas surrounding the mine site by heavy metals is described in Chapter 5. Physical alteration of the landscape was a continuous process during nearly three hundred years of mining at Avoca. However, the scale of alteration increased dramatically in the 1970s when AML excavated open pits in East and West Avoca. The large spoil heaps and open pits that resulted from these operations represented significant new visual impacts on the landscape, impacts that remain unchanged after more than twenty years. In contrast to much of the rest of the site, which has acquired significant vegetation cover over many years, the heaps and pits

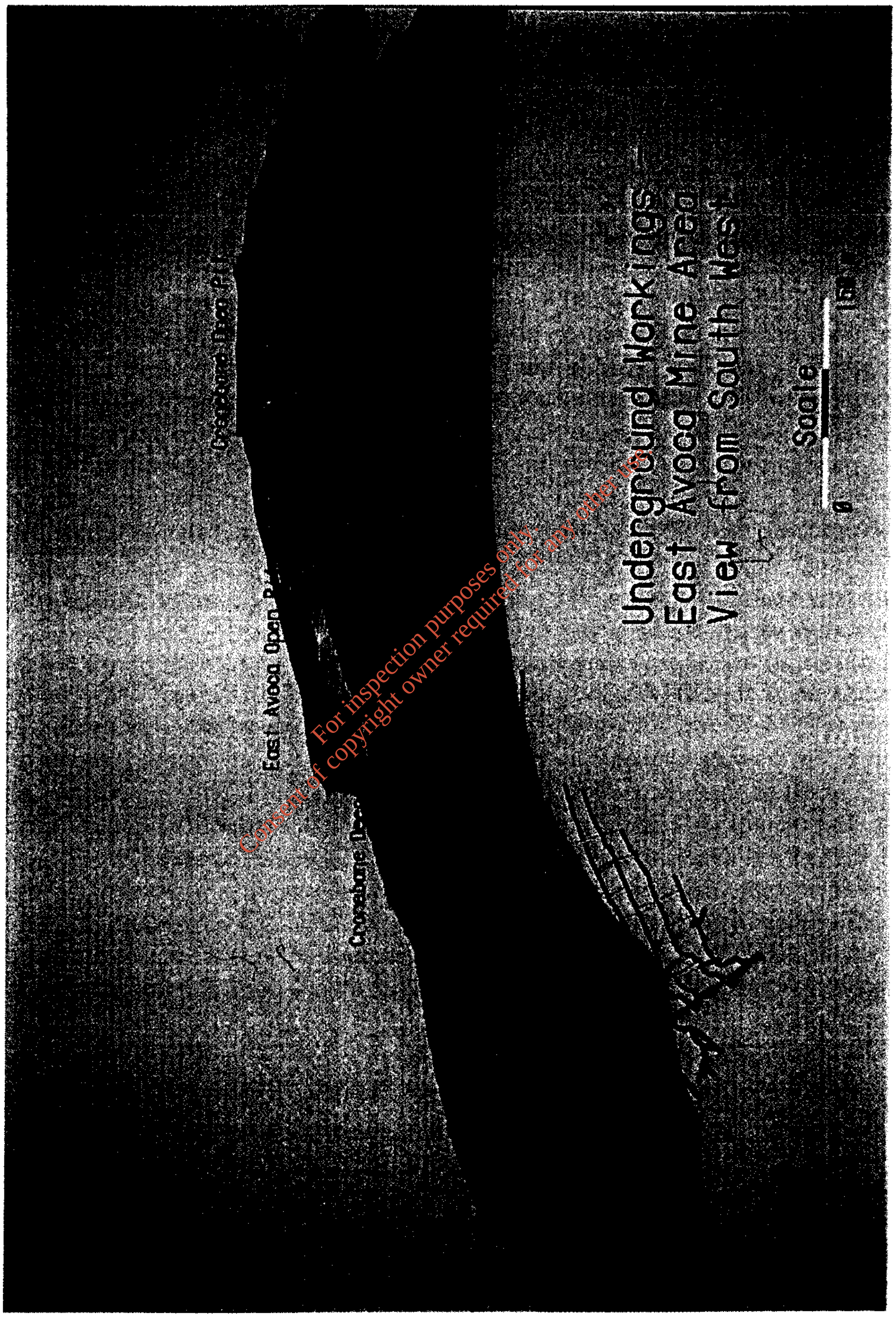


Figure 4.17 3-D reconstruction of underground mine workings, East Avoca

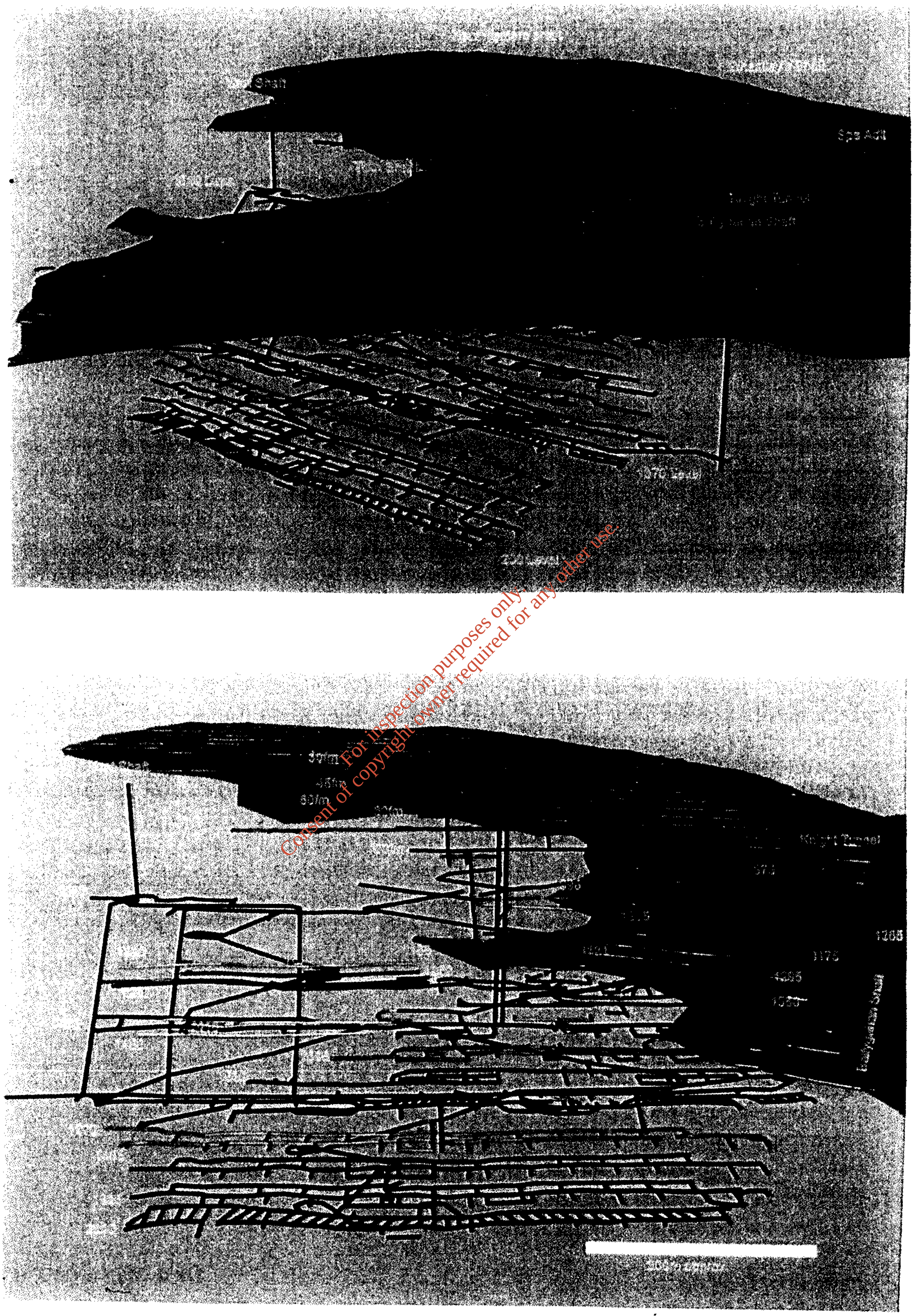


Figure 4.18 Two views of 3-D reconstruction of underground mine workings, West Avoca, from southeast (top) and south (scalebar = 200 m)

support no significant vegetation. For some, these untouched relics of mining amount to visual pollution in a valley renowned for its natural beauty. For others, they are valuable parts of the mining heritage which is an essential component of Avoca's history. These issues are discussed further in Chapter 6. Below, the sources and pathways of AMD are described and the implications discussed in the light of possible future attempts at remediation.

4.5.2 Sources and pathways of AMD

Sources of AMD

AMD is generated by the oxidation of sulphide minerals in the presence of air and water; the reaction is catalyzed by sulphur-producing bacteria. The most important mineral in this respect is pyrite which is also by far the most abundant sulphide in the mineralized rocks of Avoca. There are large volumes of sulphide-bearing bedrock and spoil exposed to air and water on the Avoca mine site. AMD is generated by leaching of bedrock sulphides principally within and around the underground mine workings where mineralized rock is still *in situ* and is accessible to water in a number of ways: 1) along cleavage planes, joints, fractures and faults in the footwall, hangingwall and country rocks; 2) in the rocks faces forming the walls, floors and roofs of 50 km of levels and shafts and an unknown volume of stopes and 3) in large but unknown volumes of mineralized waste rock left underground by 18th and 19th century miners as backfilling for stopes. The host rock sequence of volcanic tuffs contains no significant volume of carbonate lithologies that could help to buffer or neutralize AMD.

The volume and sulphur content of all such mineralized rock cannot be calculated but it is possible to estimate the amount and composition of ore-grade bedrock for most of East and West Avoca using ore reserves established by Avoca Mines Ltd. (section 3.6). For West Avoca, the calculated reserves are 4.5 million tonnes (Mt) of vein/disseminated ore (0.68% Cu, 17% pyrite) and 259,210 tonnes (t) of banded ore (0.61% Cu, 65% pyrite). The percentages of pyrite present in these ores are taken to be the same as those quoted for the different ore types by McArdle (1993). According to standard volume/weight conversion factors employed by AML, these tonnages are contained in 1,477,964 m^3 and 79,318 m^3 of rock, respectively. The ore contains some 929,863 t of pyrite and 534,161 t of sulphur, including a small component in chalcopyrite. In East Avoca, calculated reserves are 11,703,120 t of vein/disseminated ore (0.52% Cu, 17% pyrite) and 2,623,750 t of banded ore (1.37% Cu, 65% pyrite). These tonnages are contained in 3,862,030 m^3 and 802,868 m^3 of rock, respectively. The ore contains some 3,694,968 t of pyrite and 2,174,179 t of sulphur, including a contribution of about 200,000 t sulphur from sulphides other than pyrite.

Some of the figures quoted here are either drill-indicated or inferred and as such must be regarded as, at best, approximations. There is no reason to believe, however, that they are grossly exaggerated. Indeed, there is reason to regard them as an underestimate since the mineralized zones in Cronebane and Connary in East Avoca are excluded because no data are available for them. Moreover, the calculations refer to ore-grade material only, specifically copper ore, i.e. chalcopyrite-bearing rocks. They therefore exclude possibly very large tonnages of pyrite-bearing rocks that have chalcopyrite contents below a certain cut-off level (not specified) and are thus not regarded as ore.

Pathways for AMD

Most of the AMD generated in Avoca is now discharged either through the Deep Adit (East Avoca) or the Road adit (West Avoca) into the Avoca river (Fig. 4.2, 4.14). A much smaller amount is continuously discharged from Cronebane Shallow adit above and south of the rim of

East Avoca open pit, intermittently from Madam Butler's and Kilmacoo North adits in Cronebane and Connary, respectively, and from the Spa adit and Deep adit in West Avoca. Water enters the underground mine workings either as groundwater passing laterally through the rocks along cleavage planes, faults and fractures or as rainwater falling directly on the mine site and passing vertically through the roof of the mine or through open shafts. The rainwater will also percolate through spoil heaps. Where these overlie caved areas, AMD generated by leaching of spoil will pass quickly into the underground workings and thence to the river. Spoil heaps SP5, SP8 and SP10 in East Avoca are the best known examples of this. Even where spoil heaps overlie bedrock that has not collapsed, any AMD generated in them may still pass down into the mine workings, although this will be dependent on the permeability of the rock. In some cases at least, especially around Mount Platt (SP20) in East Avoca, permeability is low and the AMD emerges as springs around the base of the heap before running along the surface. It may then flow to a more permeable area, such as the base of Cronebane open pit, or simply seep into the soil in the areas surrounding the mine site. Any AMD that stays within the boundary of the mine site will most likely end up as discharge from one of the adits.

In summary, virtually all the AMD generated in Avoca, whether by leaching of bedrock sulphides or spoil heap sulphides, is eventually discharged from the mine workings into the Avoca river.

4.5.3 Discussion

The estimated volume of 6.22×10^6 m^3 of ore compares with the estimated volume 1.4×10^6 m^3 for spoil heaps in East and West Avoca (Tables 4.1, 4.2). Since the ore is much richer in sulphur, it is clear that the mineralized bedrock represents a potentially much greater source of AMD than spoil heaps. According to TCD's data (Herr and Gray 1995b), the mean concentration of SO_4^{2-} in the East Avoca Deep Adit discharge over a period of seven months in 1994 was 1596 mg l^{-1}. For a mean discharge rate of 17.2 l s^{-1} (Gray 1995), this indicates that 790 kg of sulphur *per day* are added to the river in the form of SO_4^{2-} from the Deep Adit. A similar amount is added each day from West Avoca via the Road adit. At this rate, some 7540 years would pass before the calculated *in situ* bedrock reserves of sulphur in East Avoca were leached and deposited in the river. This assumes that all the sulphur in the Deep Adit discharge is derived from bedrock. Since some comes from spoil heaps, the estimated period of time would be greater. Lower figures apply to West Avoca on account of the smaller ore reserves there. These calculations are necessarily highly simplified but serve to emphasise the importance of bedrock mineralization to the problem of riverine pollution at Avoca.

The calculations also indicate that rehabilitation of surface spoil heaps will not greatly ameliorate the AMD problem. Active treatment of discharge waters will be costly; passive treatment will require construction of wetlands at a suitable site. Rehabilitation of the river will involve a long-term commitment and significant resources.

Appendix 4.3 Underground mine workings, West Avoca

1. LEVELS AND ADITS IN 3-D DIGITAL RECONSTRUCTION

Layer (AutoCAD)	Name/description	elevation, m O.D.	map source	GSI archive no.	Developer
965RAMP	965 level to 875 level, South mine	10.5 - 37.5	AML undated	125/6/1/3/78	SPCM
995RAMP			AML undated		SPCM
DECLINE-49	1330 level to 1295 level		AML undated	125/6/1/1/45	SPCM
KNIGHT	Knight tunnel		AML 30/08/72	125/6/1/3/75	SPCM
L1035	1035 level, South mine	-10.5	SPCM	SPCM 5/452B	AML?
L1040	1040 level, South mine	-12	AML undated	125/6/1/1/2, 5	SPCM?
L1060	30 fm level, South mine	-18	MT 1951		PRE-20th C.
L1110	1110 level, South mine	-33			AML?
L1121	1121 level, South mine	-36.3	AML 2/03/71	125/6/1/1/13	SPCM
L1150	40 fm level, South mine	-45	MT 1951		PRE-20th C.
L1158	56 fm level, South mine	-47.5	AML undated	125/6/1/1/15	PRE-20th C.
L1175	1175 level, South mine	-52.5	SPCM	SPCM 5/452D	SPCM
L1180	56 fm cross-cut to North mine	-54	MT 1951		PRE-20th C.
L1220	1220 leve, South mine	-66	AML 22,25/05/74	125/6/1/1/19, 22	AML?
L1235	1235 level, South mine	-70.5	SPCM	SPCM 5/452E	SPCM
L1250	1250 level, South mine	-75	AML undated	125/6/1/1/23	AML?
L1265	Weaver's level, South mine	-79.5	AML undated	125/6/1/1/35	SPCM?
L1280	1280 level, South mine	-84	AML undated	125/6/1/1/41, 42	AML?
L1295	equivalent to 1300 level	-88.5	AML 2-9-9, 08-001-C, 08-002-C	125/6/1/1/43, 45, 48	SPCM
L1330	1330 level, South mine	-99	AML 2-18-4	125/6/1/1/50	AML?
L1350	1350 level, South mine	-105	AML 22/01/81	125/6/1/1/53	AML?
L1380	1380 level, South mine	-114	AML 9/10/81	125/6/1/4/53	AML?
L1410	Pond Lode undercut, South mine	-123	AML undated	125/6/1/4/46, 47	AML?
L1430	1430, South mine	-129	AML undated	125/6/1/4/41, 42, 45	AML?
L1450	Sub-level	-135	AML 11/05/73	125/6/1/4/36	AML?
L1505	1505 level, South mine	-151.5	AML 20/03/70, 9/05/72	125/6/1/4/33, 34	AML?
L1580	1580 level, South mine	-174	AML various, 1971 - 1972	125/6/1/4/26, 27, 28, 30	AML?
L1670	1670 level, South mine	-201	AML undated	125/6/1/4/14, 21, 24	SPCM
L1770	1770 level, South mine	-231	AML 17/01/78, 22/01/75	125/6/1/4/9; 125/6/1/2/1	AML
L1845	1845 level, South mine	-253.5	AML 22/01/76, 13/07/77	125/6/1/2/6, 11	AML
L1920	1920 level, South mine	-276	AML 22/01/76, 13/07/77	125/6/1/2/15, 21	AML
L2000	2000 level, South mine	-300	AML 14/07/77, 23/01/76	125/6/1/2/26, 30	AML
L500	Pump discharge adit, North Lode	150	MT 1951		PRE-20th C.
L530	£0 fm level, North Lode	141	MT 1951		PRE-20th C.

L540	460' level, Weaver's Lode	138	MT 1951		PRE-20th C.
L570	Adit to W. Whim shaft, North Lode	171	MT 1951		PRE-20th C.
L610	42 fm level, South mine	117	MT 1951		PRE-20th C.
L620	Spa adit, Weaver's Lode	114	MT 1951	125/6/1/3/56	PRE-20th C.
L670	53 fm level, South mine	99	AML undated	125/6/1/3/55	PRE-20th C.
L720	Margaret adit	84	AML undated; MT 1951		PRE-20th C.
L790	80 fm level, North Lode	63	MT 1951		PRE-20th C.
L830	260 fm level, South mine	51	AML undated	125/6/1/3/67	PRE-20th C.
L875	875 level, South mine	37.5	AML undated	125/6/1/3/69	SPCM
L890	100 fm level, North Lode	33	MT 1951		PRE-20th C.
L894	Road adit, South mine	32	MT 1951		PRE-20th C.
L900	Ballygahan Deep adit	30	MT 1951		PRE-20th C.
L950	112 fm level, North Lode	15	MT 1951		PRE-20th C.
L990	18 fm level, South mine	3	SPCM		PRE-20th C.
L995	995 level, South mine	1.5	MT 1951		SPCM
MAINDECLINE	main decline below Knight tunnel		AML 30/08/72	125/6/1/3/75; 125/6/1/2/29	AML
OREPASS	orepasses, South mine				SPCM/AML
PONDECLINE	Pond Lode decline				AML

2. REMAINING SHAFTS

Shaft	Layer (AutoCAD)	Type: V/I/VI	Elevation, m O.D.		
			top	hinge	bottom
Ballygahan	shaft_ballygahan	V	60		-210
Drawing	shaft_drawing	V	129		84
New western	shaft_new-western	V	189		141
Twin: Drawing	shaft_twin_drawing	VI	131	-90	-170
Twin: Engine	shaft_twin_engine	VI	131	-90	-201
Vent	shaft_vent	VI	138	-12	-201
Wheatley's	shaft_wheatleys	VI	168	120	63
Whelan's	shaft_whelans	VI	159	138	114
V: vertical					
VI: vertical + inclined					
I: inclined					

BALLYMURTAGH OPEN PIT

GENERAL DESCRIPTION & ESTIMATE OF COST

OF

THE PROPOSED WASTE DISPOSAL SITE

LANDFILL DESIGN AT BALLYMURTAGH OPEN PIT AVOCA CO. WICKLOW

1.0 Site Description:

The Ballymurtagh open pit is a disused mine excavation which was developed to exploit the Pond Lode in West Avoca. The pit itself covers approximately 1 hectare which is fully enclosed by a high chain link perimeter fence some 1,370 m. long and covering some 8 hectares. The open pit is a long (180 m.), narrow (55 m.) excavation which is nearly fully enclosed by high walls of rock and mine waste.

The floor of the Ballymurtagh open pit is a flat surface which results from its use as a settlement pond for liquid mine wastes, with up to 16.5 m. of tailings occuring beneath the present floor. The tailings, which are mainly in the silt range (0.002-0.06 m.m.), have infilled the deeper parts of the open pit and now have a thin covering layer of overburden. While the tailings were in a liquid state when pumped to the open pit for settlement, drainage through the base of the open pit has allowed the tailings to dry out and consolidate. Standard penetration tests carried out during the drilling operations associated with this study indicate that the tailings are now in a medium dense condition and only show signs of softening in the deeper levels below 6 m. This process of consolidation will continue as further drainage takes place.

The present open pit floor is dry and except for a few seepages from the enclosing walls the excavation is devoid of water. Some isolated ponding of rainwater does take place on the open pit floor where the thin layer of overburden has been compacted by truck movements.

1.1 Pit Floor Drainage:

The pit floor in periods of high rainfall becomes saturated with a considerable amount of standing water indicating the impermeability nature of the tailings material. This property which is advantageous in controlling the rate of seepage of generated leachate will cause operational and construction difficulties.

In order to provide a satisfactory working base for the construction and operation of the open pit, it will be necessary to install land drains below the present level of the pit floor approx. 1.5 m. deep on average at a spacing of 18 m. The purpose of these land drains is twofold :-

(a) To improve the bearing capacity of the tailings;

(b) To provide for better soakage of the leachate.

We would propose to lay 2 No. longitudinal drains 15 m. apart 1.5 m. deep and 600 m.m. wide filled with 19.25 m.m. crushed stone and surround with "Terram" 700 acting as a filter medium.

1.2 Pit Floor Bearing Capacity:

The tailings forming the pit floor at present are only partially compacted and would not form a satisfactory working base. It is proposed to improve this by means of a separating membrane of Terram 1000 on which a graded granular layer 500 m.m. thick sub-base is placed and compacted. This sub-base will then provide a base on which the generated leachate can be dispersed laterally into the drains and tailings. The separating membrane will prevent loss of the granular material into its mine tailings. The specification of the 500mm layer shall be crushed stone graded 100mm to 12mm. This is likely to be its most costly part of the developement costs of this land fill site and on the site trial tests should be carried out to determine if some of its on site material could be used in its upper 200mm as stated above. The purpose of this layer is two fold, one to provide a working base to carry the imposed truck loading and two, to provide for lateral dispersal of generated leachate. The thickness of the free draining layer would be adequate at 300mm

1.3 <u>Containment of Leachate:</u>

The Ballymurtagh site is designed to operate as a dilute and disperse site i.e. its leachate to filter through the mine tailings, in the base into its mine working shafts and there diluted by the mine waters.

To ensure that the leachate is contained in this path it is proposed to construct a bund at the Eastern end of the pit. The bund should be raised to the level of 5 meters over the base of the pit and shall be lined on the pit side by means of a Butyl Rubber Lining. The lining shall be roughly 2 meters below the present floor of the pit. On top of the impermeable lining a free draining layer of stones shall be placed to ensure that any liquid reaching the face of the bund is drained off into the drains running back into the pit.

1:4 **Gas Dispersal**

Landfill gas consisting principally of methane and carbondioxide is a natural product of land fill sites. The design includes a venting system consisting of a stone filled column with perferated collecting pipes as shown in detail D.5., to ensure safe dispersal of the gases into the atmosphere. The pipes shall be extended upwards as the pit is filled.

1:5 **Security Fencing**

The main pit at present has a concrete post and a chain link fence with 3 strands of barbed wire security fence all around. It is proposed to extend this fencing out to the entrance gate and around the entrance facilities and to link it back with the existing fence.

Portions of the existing fence have been removed or damaged and it is proposed to make these sections good.

1:6 Site Facilities

The site has been laid out with the minimum visibility from the Arklow Rathdrum Road. It is proposed that the site be indicated by sign posts on this road and with a finger post sign at the entrance. A new entrance is to be constructed at the site and it will improve visibility. The site entrance proper is to be set back beyond where the housing access road meets the main access road. It is proposed at this point to erect a sign showing hours of opening charges etc and a cattle grid and peers will define the start of the site. The access road is to be laid to a good standard to encourage full usage of the land fill site. The main site buildings will be constructed on the platue level of 63M.O.D. and partially screened from the road. These include site office, wheel wash and weigh bridge and a week- end facility. The site proper is not to be opened over the full week end and it is proposed that domestic use at weekends would be into two collection skips. These collection skips would then be transported to the main pit at the beginning of the working week.

In normal operation all waste would be directly disposed of into the main pit. Domestic use would be at the turning circle directly beyond the screen bund and industrial use along the access road directly into the pit.

Preparation of Land Fill Base

	UNIT	QUANTITY		RATE £	£	
A	sq.mtrs.	11000	The base of the pit shall be graded to effect an even surface by means of a tracked machine to remove all irregularities.	.50	5,500	00
B			The floor of the pit shall then be drained as described and measure under land drainage			
C	sq.mtrs.	11,000	Provide and lay "Terram 1000" over the entire area of pit and turned up 1 metre at all edges. Laps between sheet to be 0.5m all in accordance with detail D3	.45	4,950	00
D	sq.mtrs.	10,000	Provide, lay and compact crushed stone graded 100mm. to 12mm. - a layer .5m thich minimum over the entire area to base of pit.	5.00	50,000	00
E	sq.mtrs.	650	Provide and lay 1mm. Butyl Rubber impermeable membrane to face screened band as shown on detail D4	8.00	5,200	00
F	sq.mtrs.	650	Provide and lay 300 mm layer of free draining stone graded 40 mm to 20 mm to detail D4	3.00	1,950	0
G	sq.mtrs.	650	Provide and lay Terram 700mm Filter Membrane to detail D4	.50	325	0
H	sq.mtrs.	650	Provide and lay 75 mm thick layer of coarse sand to detail D4	1.00	650	0
I	No	4	Provide and erect 4 no. gas dispersal chambers with extension pieces to monitoring bore holes to detail D5	500.00	2,000	0
J	lin m	505	Provide and lay gas collecting pipework to gas dispersal chambers to detail D5	5.00	2,525	0
			To Summary		£73,100	0

Site access and road works.

	UNIT	QUANTITY			£	
A	Item		General site clearance removal of rubble, demolition of walls, general grading to improve access.		200	00
B	Lin.m	235	Removal of fencing and post, storing for re erection.	3.00	705	00
C	cu.mts.	19456	Bulk excavation on site to provide fill material to embankments and sub-base to road. The material to be excavated shall be taken from the South section of the pit. This area shall be reduced to the levels required for the access road and the additional material taken from higher ground to the North WEst. The material excavated shall be pushed or hauled and deposited along the entrance road and embankments to form the sub-base for the road. The material shall be deposited in layers not greater than 200mm in spread and compacted in accordance with clause 609 of the D.O.E. spec for road works.	1.50	29,184	00
D	cu.mts.	500	Extra over item C for excavation in rock.	10.00	5,000	00
E	sq.mts.	4255	Provide and lay 300mm min thickness base course of granular material type B to clause 804. Layed and compacted in accordance with clause 802.	3.00	12,765	00
F	sq.mts.	3522	Provide and lay 500mm Dense Base course Macadam in accordance with clause 802.	5.50	19,371	00
				c/f	67,225	00

				b/f	67,225	00
G	sq.mts.	4230	Provide and lay 2 no Surface Dressing Coats in accordance with clause 908.	2.50	10,575	00
H	lin.mts	1180	Provide and lay precase concrete kerbs to B.S.340 set; jointed and painted in cement mortar on and including 150mm bed of concrete mix no. 20, 350mm wide concrete haunching size 250mm x 250mm to back of kerbs, to detail D6, including curving.	10.00	11,800	0
I	Item		Provide and install cattle grid to entrance to detail D7.		1,500	0
			To Summary		£91,100	0

Land Drainage

A	lin.m	380	Excavate trenches in base of pit to receive free draining crushed stone 600mm wide by 1.5 metres deep.	12.00	4,560	00
B	lin.m.	380	Provide and lay "Terram 700" filter membrane in trunch as shown detail 2170/D1 4.5m wide	.50	190	00
C	cu.m	342	Provide and lay crushed stone graded 40mm to 20 mm in trench and compact.	10.00	3,420	00
D	lin.m	70	Excavate trench to base of screen bund to receive free draining crushed stone 600 mm. wide by 1.5m.deep	12.00	840	00
E	lin.m.	70	Provide and lay "Terram 700" filter membrane in trench as shown on detail 2170/D1 4.5m.wide	.50	35	00
F	Cu.m.	63	Provide and lay crushed stone graded 40 mm to 20 mm in trench and compact.	10.00	630	00
G	lin.m	50	Excavate trench 300 wide x 300 deep on side slopes through top soil, lay "Terram 700" 2.25m wide, fill with crushed stone graded 40 mm to 20mm and close Terram across all as shown on detail D2 attached	5.00	250	00
			To Summary		9,925	00

	UNIT	QUANTITY		RATE	£	
			Surface Water drainage.			
			Provide and lay surface water sewer along road as shown on drawings.			
			225mm diameter Wavinsewer average depth 1.5m.			
A	Lin.m	422		12.00	5,064	00
			375mm diameter sewer average depth 1.75m.			
B	Lin.m	98		30.00	2,940	00
			S.W. Manholes to detail.			
C	No.	7		700.00	4,900	00
			Headwall at conneection to river.			
D	No	1			600	00
			Cut off drain at top road to be connected to mine shaft.			
E	Item				1,000	00
			Precast concrete road gullies and frames with connecting pipe work to detail.			
F	No.	15		350.00	5,250	00
			To Summary		£19,754	00

Site Services

			Watermain Connect to existing watermain at entrance include for providers 75mm Tee connection 75mm sluice valve and valve chamber.			
A	Item				500	00
			Provide and lay 75mm Wavin water main along road base to entrance hut, average depth below finished road level 800mm.			
B	Lin m	390		£8.00	3,120	00
			Provide and install booster pump in entrance hut to provide supply to canteen and toilet.			
C	Item				400	00
			Rising main to canteen 25mm dia laid in road average depth 500mm.			
D	Lin m	150		4.00	600	00
			Plumbing to connections 12mm to canteen sink 12mm to W.C. and W.H.B. 18mm to Bik cock 2 No. 18mm to Wheel wash.			
E	Item				800	00
			Provide 1 No flanged hydrant and Tee and chamber to I.S.123			
F	No.	1			400	00
			To Summary		£5,820	00

Site Facilities.

		Provide the P.C. sum of £15,000 for the provision and installation of a weight-bridge.		
A	Item		£15,000	00
		Extra over item A for weight-bridge building work.		
B	Item		4,950	00
		Provide and construct wheel-wash to detail.		
C	Item		9,600	00
		Provide and construct canteen and toilet to detail.		
D	Item		3,230	00
		Provide and construct entrance hut to detail.		
E	Item		2,450	00
		Bottle Bank to detail.		
F	Item		400	00
		Waste Oil Recovery Drill to detail.		
G	Item		350	00
		To Summary	£35,980	00

Electrical

			To amount for obtaining single phase electrical supply from E.S.B.			
A	Item.				2,000	00
			Provide and lay underground ducting from supply point to external compound and canteen building.			
B	Lin.M	540		5.00	2,700	00
			P.C. sum for electrical work including, 4 No. external standards. 4 No. power sockets. 3 No. lights.			
C	Item				2,900	00
			To Summary		7,600	00

Fencing and Gates.

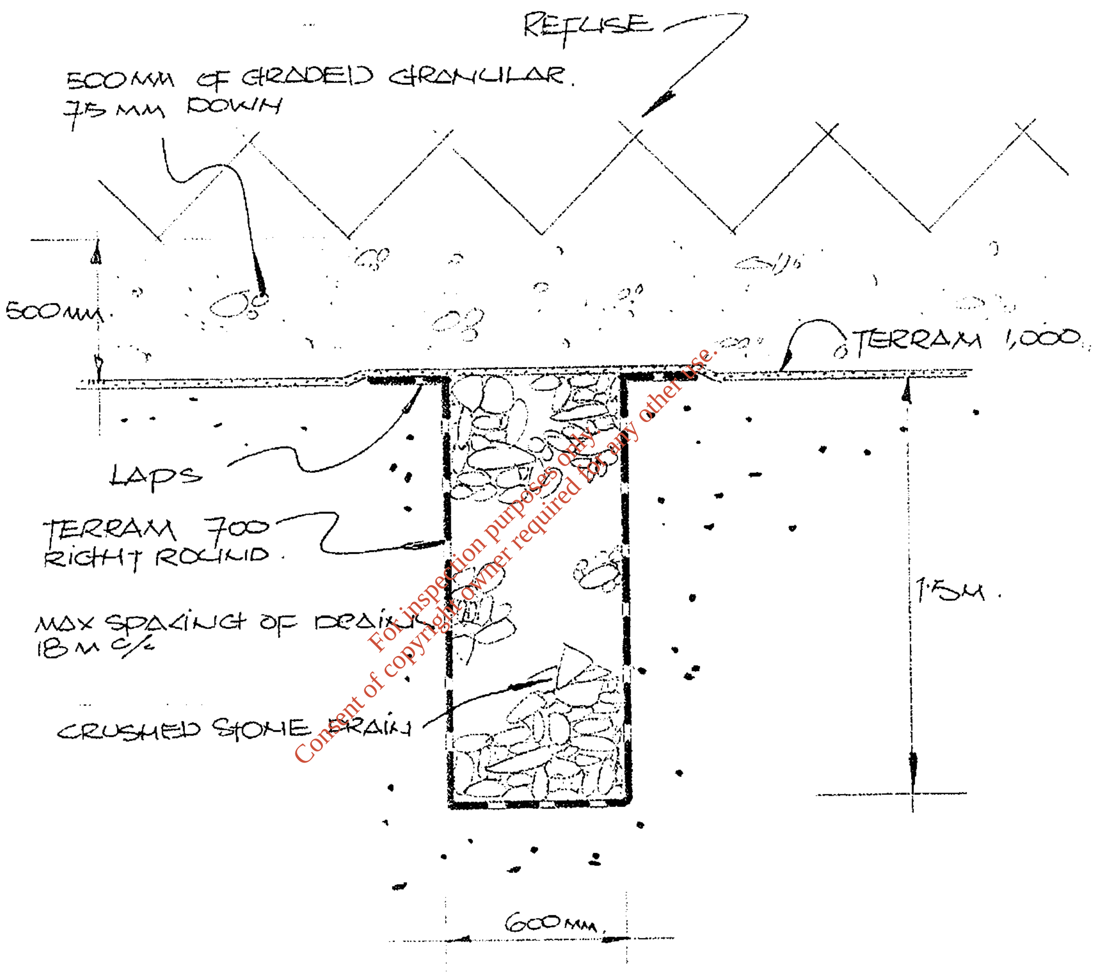
	Unit	Quantity	Description	Rate	£	
			Provide and install 2.4 metre high standard security concrete fencing with chain link mesh and 3 strands barbed wire to match existing, to detail.			
A	Lin.m	300		10.00	3,000	00
			Make good to existing security fencing to secure entire site.			
B	Item.				1,000	00
			Provide and install litter screen fencing on Spruce Poles 4.75 high to detail.			
C	Lin.m	120		10.00	1,200	00
			Provide and install entrance gates to detail.			
D	No	2		50.00	1,700	00
			Provide and install gate to skip compound.			
E	No	1		00.00	800	00
			To Summary		£7,700	00

I

	UNIT	QUANTITY		RATE	£	p
			Summary			
amount		for	Preliminaries and Insurances	not included		
"		"	Contingency sum		20,000	00
"		"	Preparation of land fill Base		73,100	00
"		"	Site Access and Road Works		91,100	00
"		"	Land drainage		9.925	00
"		"	Surface water drainage		19,754	00
"		"	Water main		5,820	00
"		"	Site Facilities		35,980	00
"		"	Electrical Works		7,600	
"		"	Fencing and Gates		7,700	00
"		"	Landscaping		10,000	00
"		"	Design fees	not included		
"		"	Monitoring costs	not included		
"		"	Land costs	not included		
			Total (excl v.a.t.)		£280,979	00

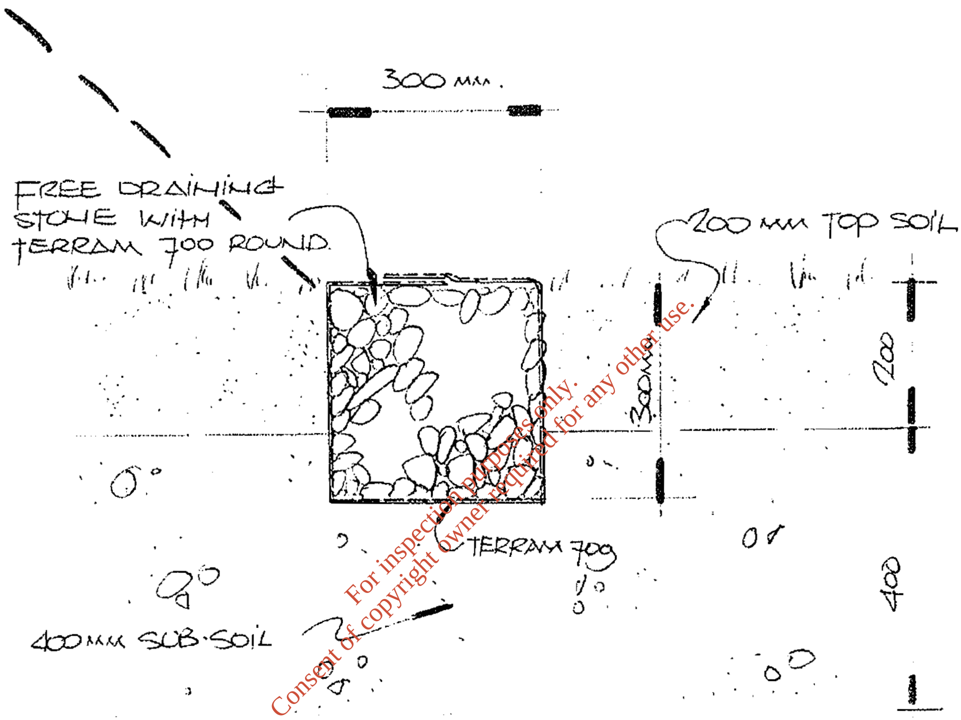
This estimate is based on current building costs (April 1988). A number of items above have been excluded as noted owing to lack of information and should be added to the final overall costing. Value Added Tax has also not been accounted for.

Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel ; (0902) 74264 or 78422	job BALLYMURTAGH OPEN PIT			job no 2170
	title PIT BASE DRAIN DETAIL .			drg no
	rev SCALE: 1/25.	date MARCH '1988	by JD .	D1.



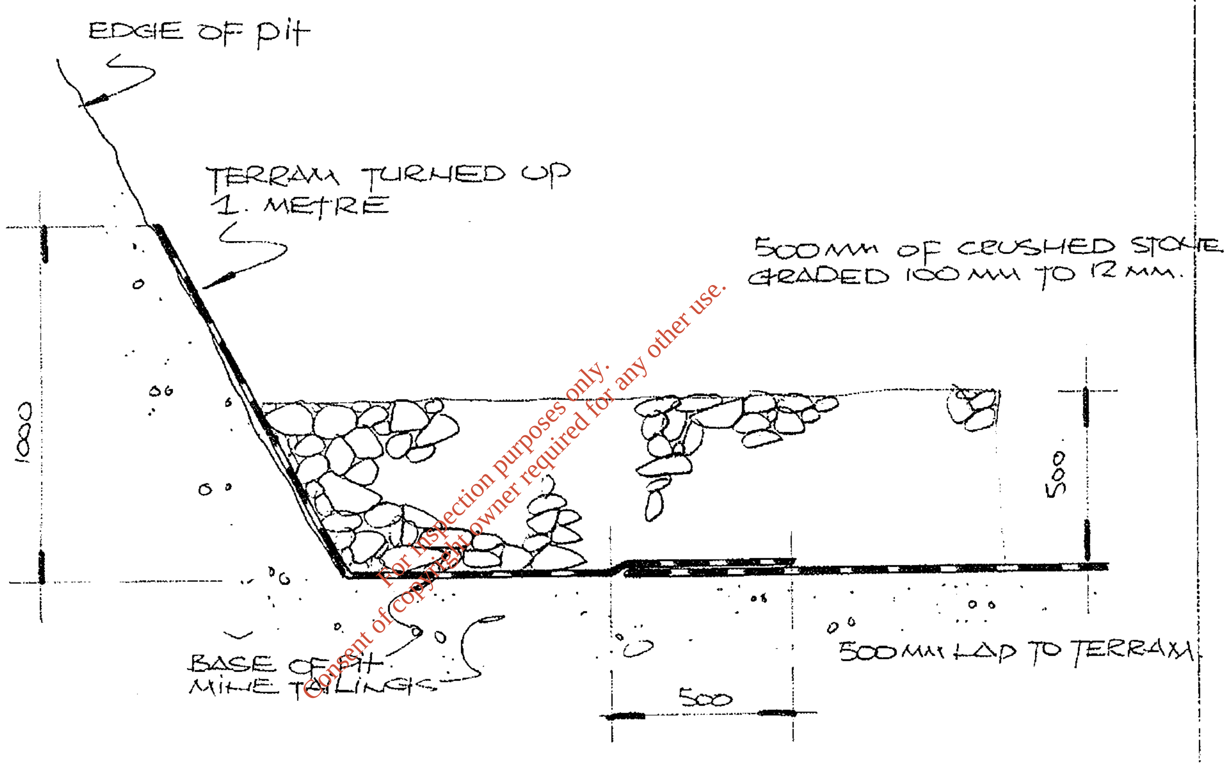
DETAIL OF DRAIN . THRO' PIT FLOOR
2 No THUS .

Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place. Athlone. Tel: (0902) 74264 or 78422	job BALLYMURTAGH OPEN PIT			job no 2170.
	title LAND DRAIN DETAILS.			drg no
	rev 1/10.	date APRIL 1988	by JD.	D. 2.



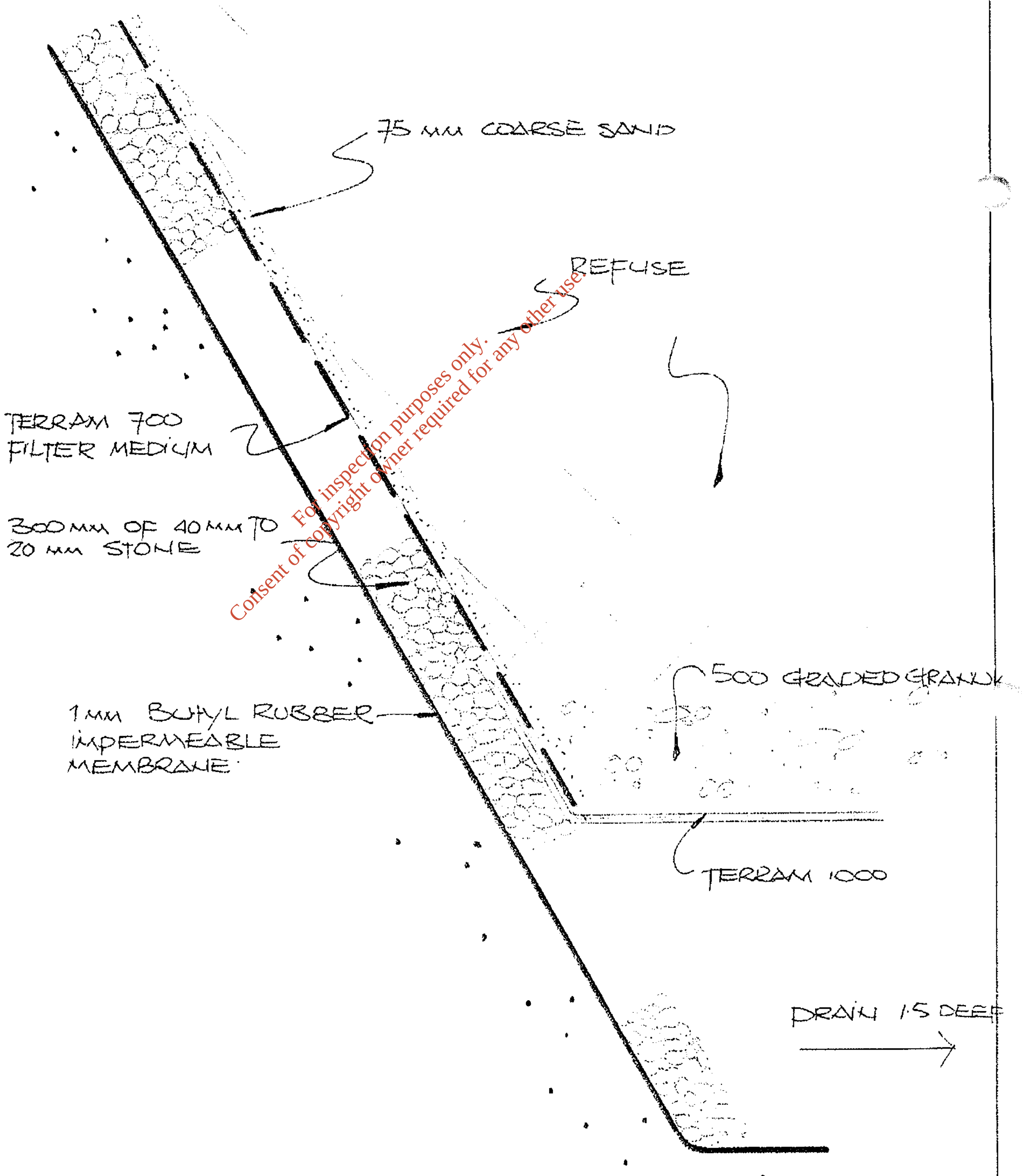
LAND DRAIN TO FACE OF SCREEN BUND.

Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel: (0902) 74264 or 78422	job BALLYMURTAGH OPEN PIT. title EDGE OF PIT DETAIL	job no 2170
	rev 1/20. | date APRIL 1988 | by JD.	drg no D. 3.



DETAIL AT EDGE OF PIT.

Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel ; (0902) 74264 or 78422	job BALLYMURTAGH OPEN PIT.			job no 2170.
	title DETAIL AT SIDES OF PIT.			drg no
	rev	date MARCH 1988	by JD.	D4



SIDE DETAILS.
FRONT BUND.

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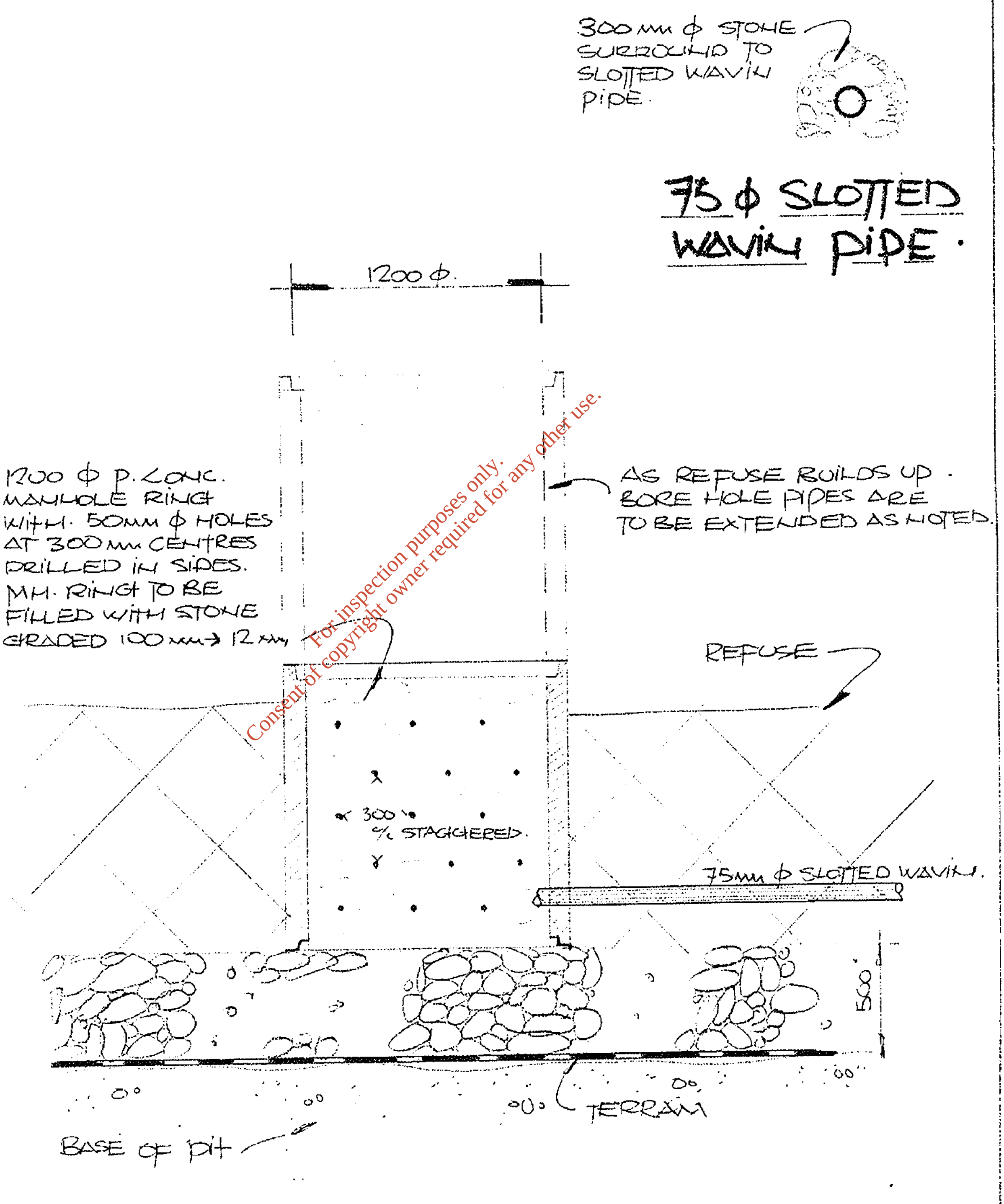
Tel: (0902) 74264 or 78422

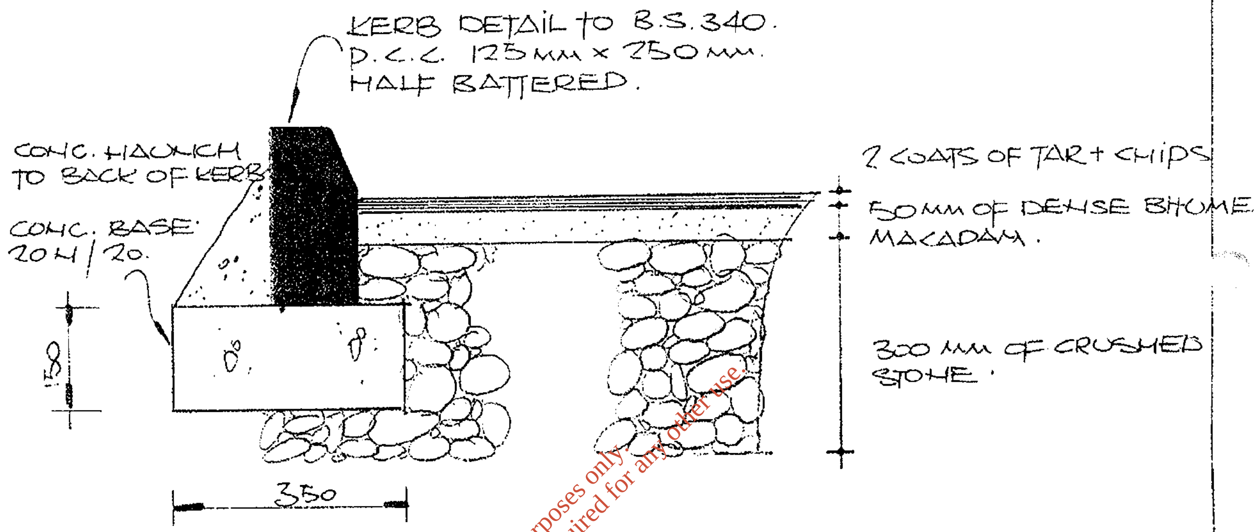
job	job no
BALLYMURTAGH OPEN PIT	2170.
title	drg no
GAS DISPERSAL CHAMBERS	D5.
rev: 1/25. date: APRIL 1988 by: JD.	



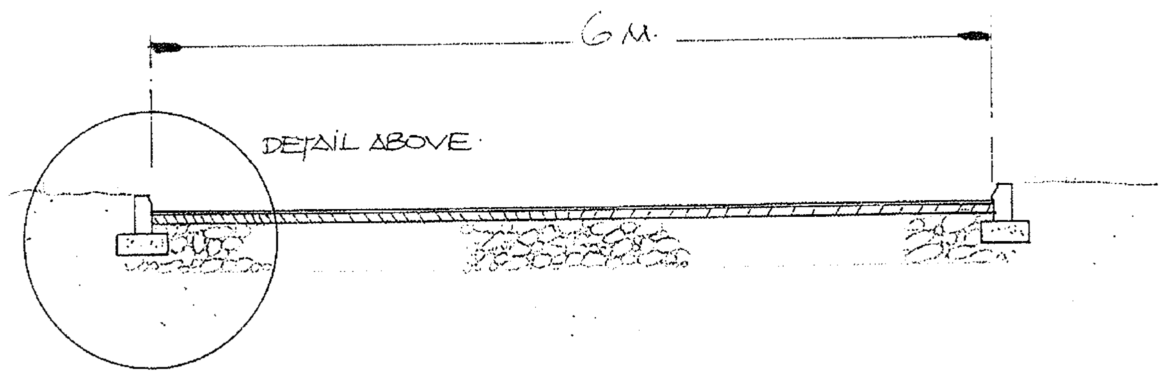
GAS DISPERSAL CHAMBER

4. No. THUS.

Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel: (0902) 74264 or 78422	job BALLYMURTAGH OPEN PIT		job no 2170
	title ROAD & KERB DETAILS.		drg no
	rev 1/10 1/50	date APRIL 1988	by JD.
			D.C.



ROAD & KERB DETAIL.



TYPICAL ROAD SECTION.

(NOTE ROAD ABOVE PEOPLES FACILITY TO BE 4M WIDE ONLY & NOT KERBED.)

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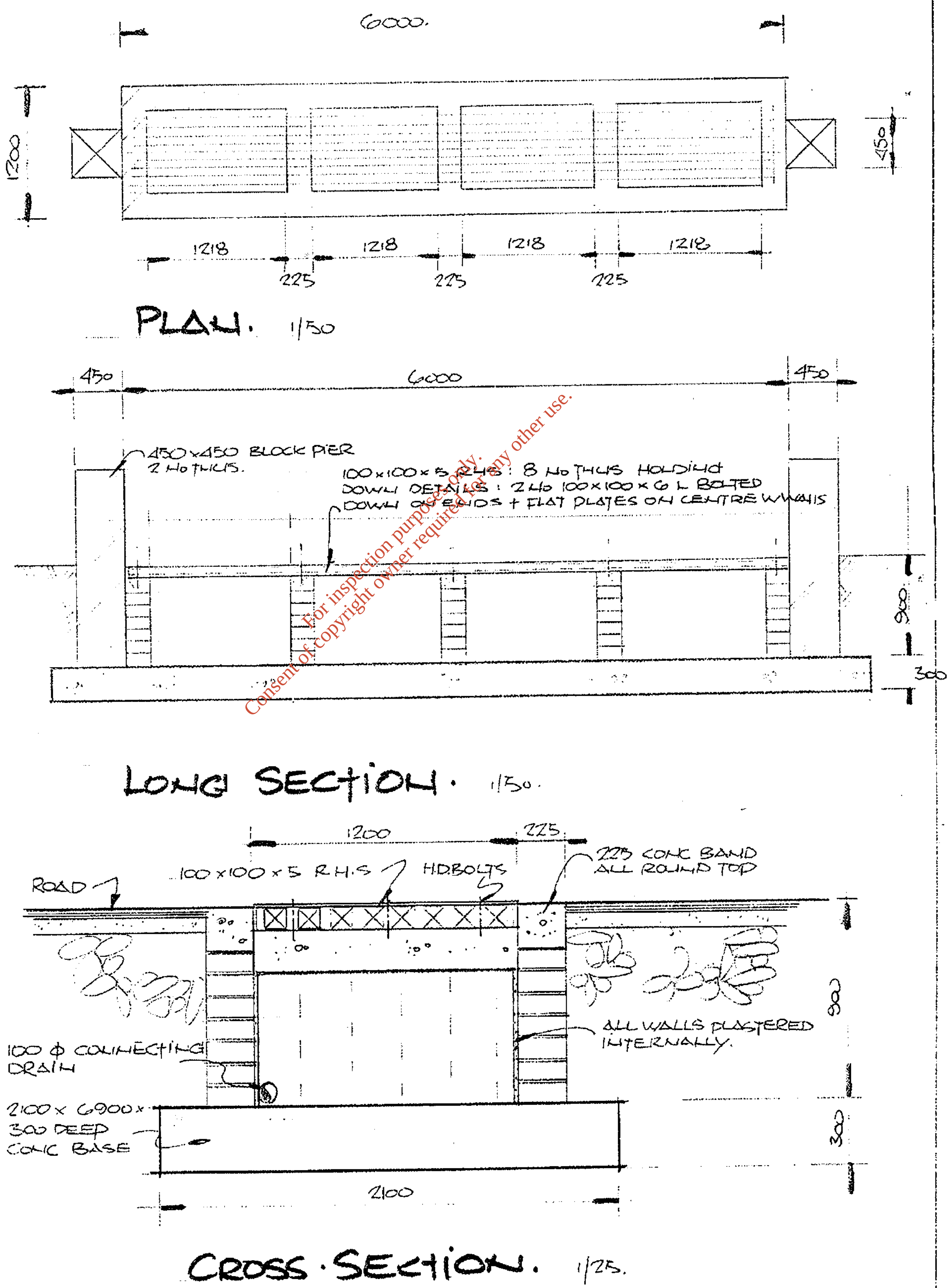
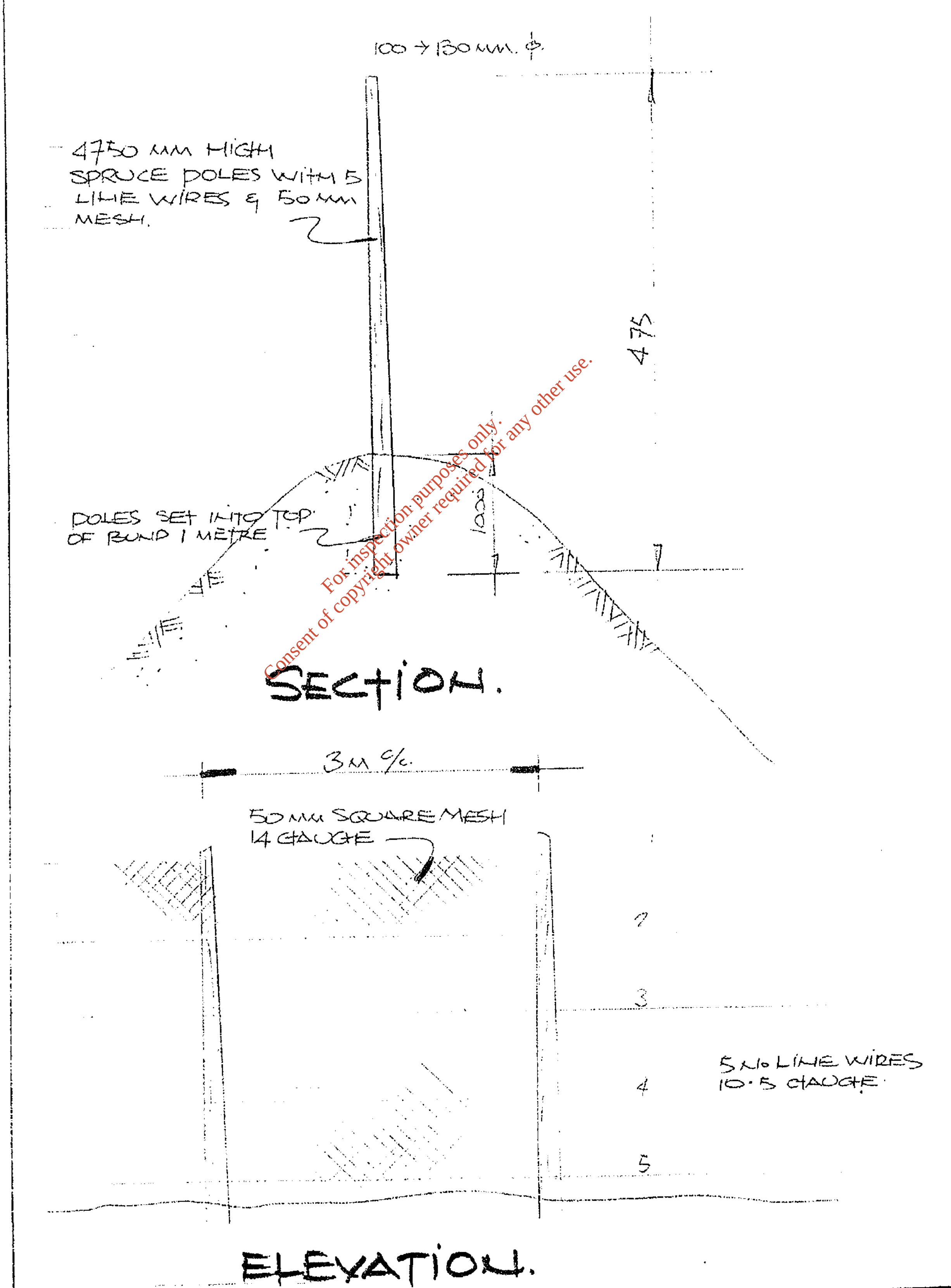
CONSULTING ENGINEERS
15 Custume Place, Athlone.
Tel: (0902) 74264 or 78422

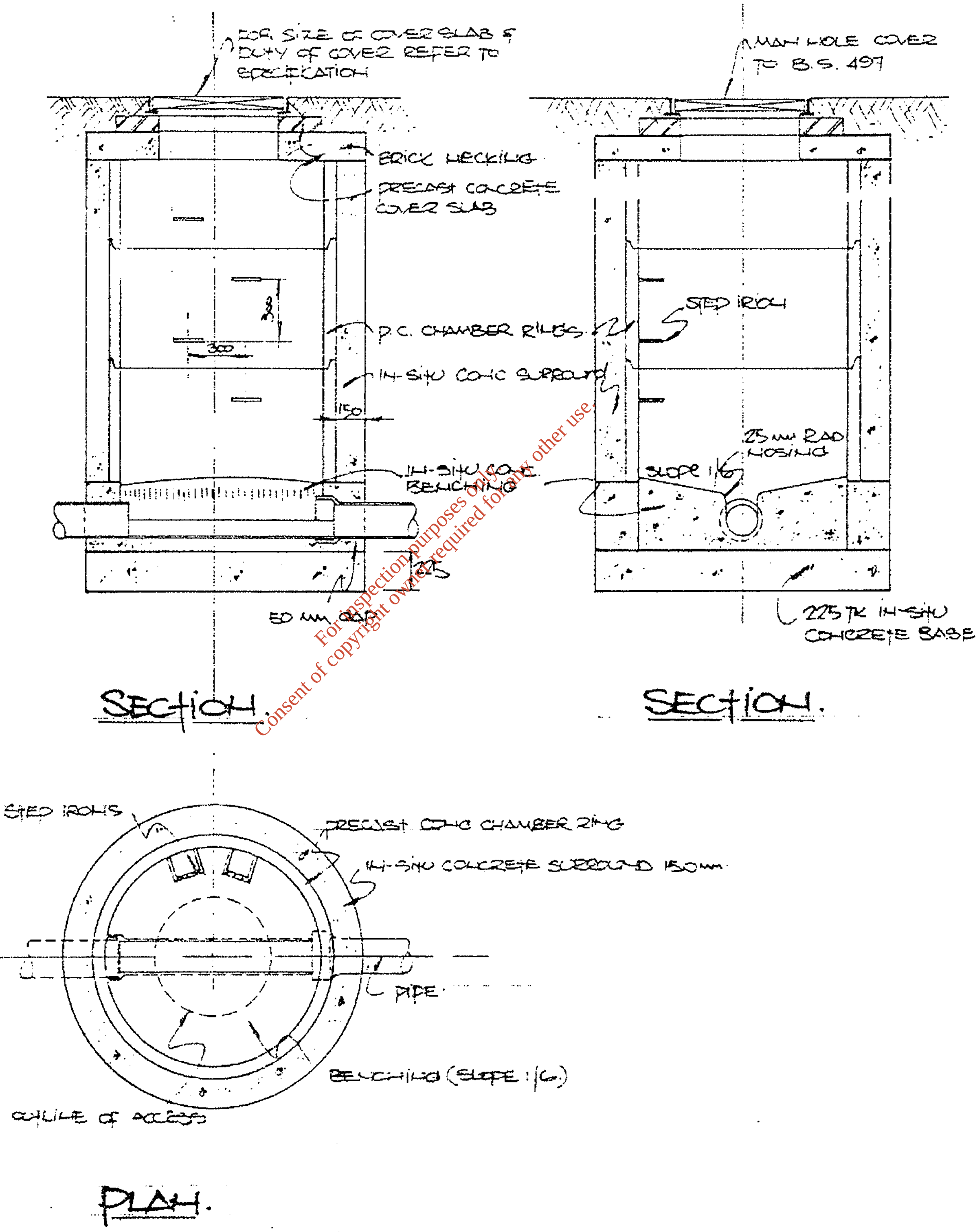
job	BALLYMURTAGH OPEN PIT.
job no	2170.
title	CATTLE GRID. (1 No THUS.)
drg no	D7.
rev	1/50 1/25
date	APRIL 1988
by	JD.



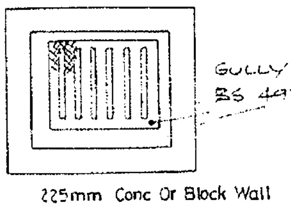
Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel: (0902) 74264 or 78422	job BALLYMURTAGH OPEN PIT			job no 2170
	title LITTER SCREEN FENCING			drg no
	rev	date APRIL 1988	by JD.	D8.



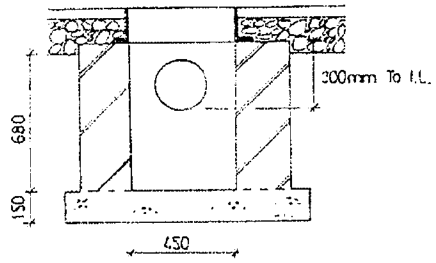
Malachi Cullen Assoc.	job	BALLYMURTAGH OPEN PIT.		job no
CONSULTING ENGINEERS	title	MANHOLE DETAILS.		2170.
15 Custume Place, Athlone.	rev	date	by	drg no
Tel: (0902) 74264 or 78422	N.T.S.	APRIL 1988	J.D.	SK.1.



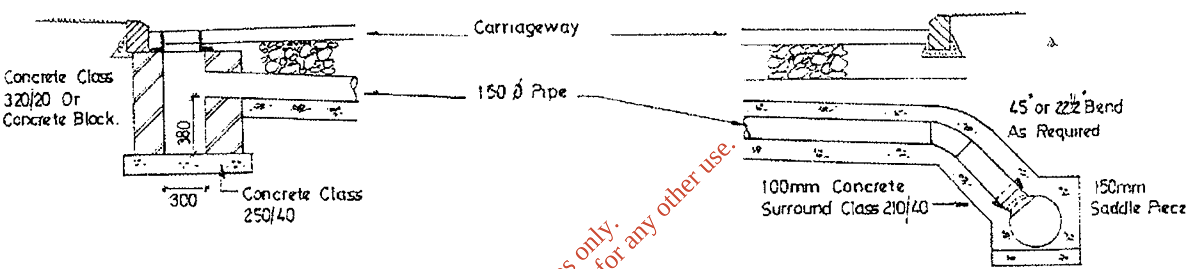
Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel: (0902) 74254 or 78422	job BALLYMURTAGH OPEN PIT.	job no 2170
	title ROAD GULLY DETAILS.	drg no SK-2.
	rev N.T.S · date APRIL 1988 · by JD.	



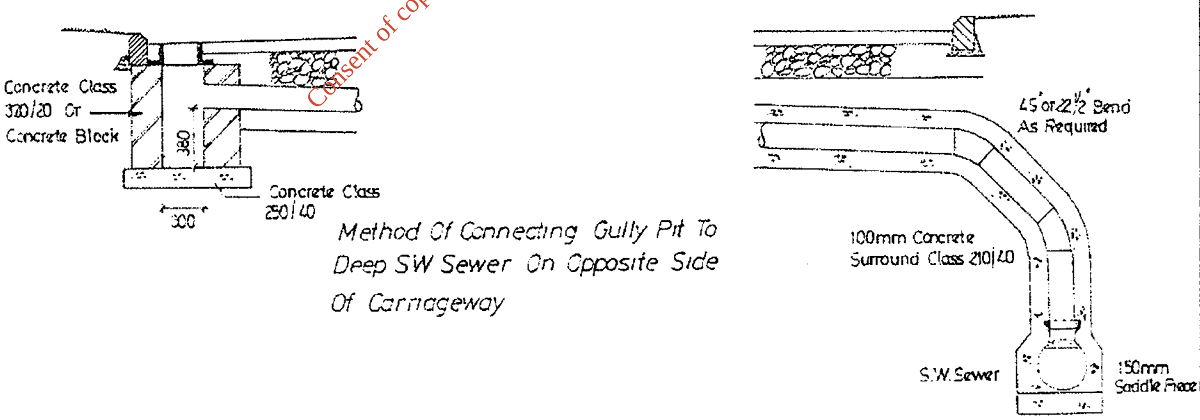
Plan



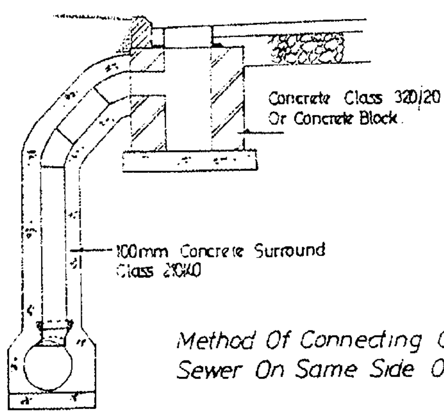
Section



Method Of Connecting Gully Pit To S.W. Sewer On Opposite Side Of Carriageway



Method Of Connecting Gully Pit To Deep SW Sewer On Opposite Side Of Carriageway



Method Of Connecting Gully Pit To S.W Sewer On Same Side Of Carriageway

JDH

Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel: (0902) 71264 or 78422	job BALLYMURRAGH OPEN PIT	job no 2170
	title MANHOLE COVERS + FRAMES	drg no
	rev N.T.S. / date APRIL 1988 / by JD	SK-3.

Manhole Covers & Frames

Manhole Covers And Frames Shall Be As Approved And Unless Specified Otherwise Shall Comply With B S 497 In All But Dimensions The Minimum Opening Dimensions Shall Be 600mm X 600mm Rectangular Or If Circular 550mm Diameter The Appropriate Grade Of Cover And Frame Which Shall Be Used In Any Location is Given In Table 1

TABLE 1 Manhole Covers And Frames

B S 497 Grade	Location
Grade A	Carriageways
Grade B	Footpaths Verges Vehicular Accesses
Grade C	Situations Inaccessible To Wheeled Vehicles

Table 2 Sluice Valve And Stopcock Boxes

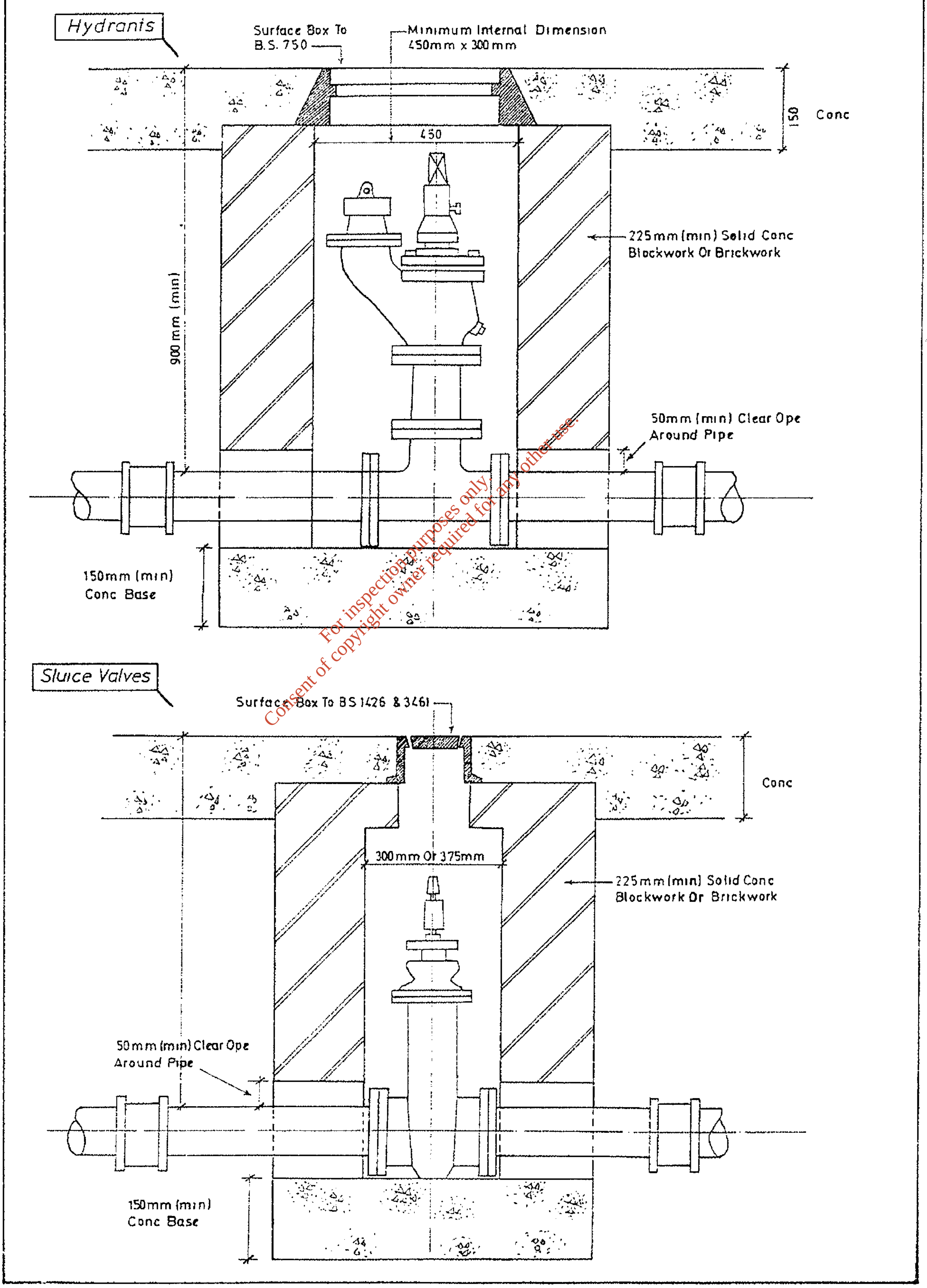
B S 1426 And 3461 Grade	Location
Heavy Type H	Carriageways
Medium Type M	Footpaths Verges Vehicular Accesses
Light Type A	Situations Inaccessible To Wheeled Traffic

Indicator Plates And Marker Posts

Hydrants Air Valves And Sluice Valves Shall Be Located By Indicator Plates Positioned To The Approval Of The Local Authority, Hydrant Indicator Plates Shall Be Single Hydrant Indicator Plates With Fixed Black Letters Complying With B.S.3521 Except That The Plates Shall Be White. Air Valve And Sluice Valve Indicator Plates Shall Comply With The Specification For Single Hydrant Indicator Plates With Fixed Letters in B.S.3521 Except That They Shall Be Coloured White And Instead Of The Letter H Shall Bear The Letters A V And S V Respectively As Approved.
Where Marker Posts Are Used They Shall Be Concrete Complying With I.S.162.

JDH

Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel ; (0902) 74264 or 78422	job: BALLYMURTAGH OPEN PIT	job no: 2170
	title: HYDRANT & SLUICE VALVE	drg no: SK-4
	rev: NTS / date: APRIL '88 / by: JD.	



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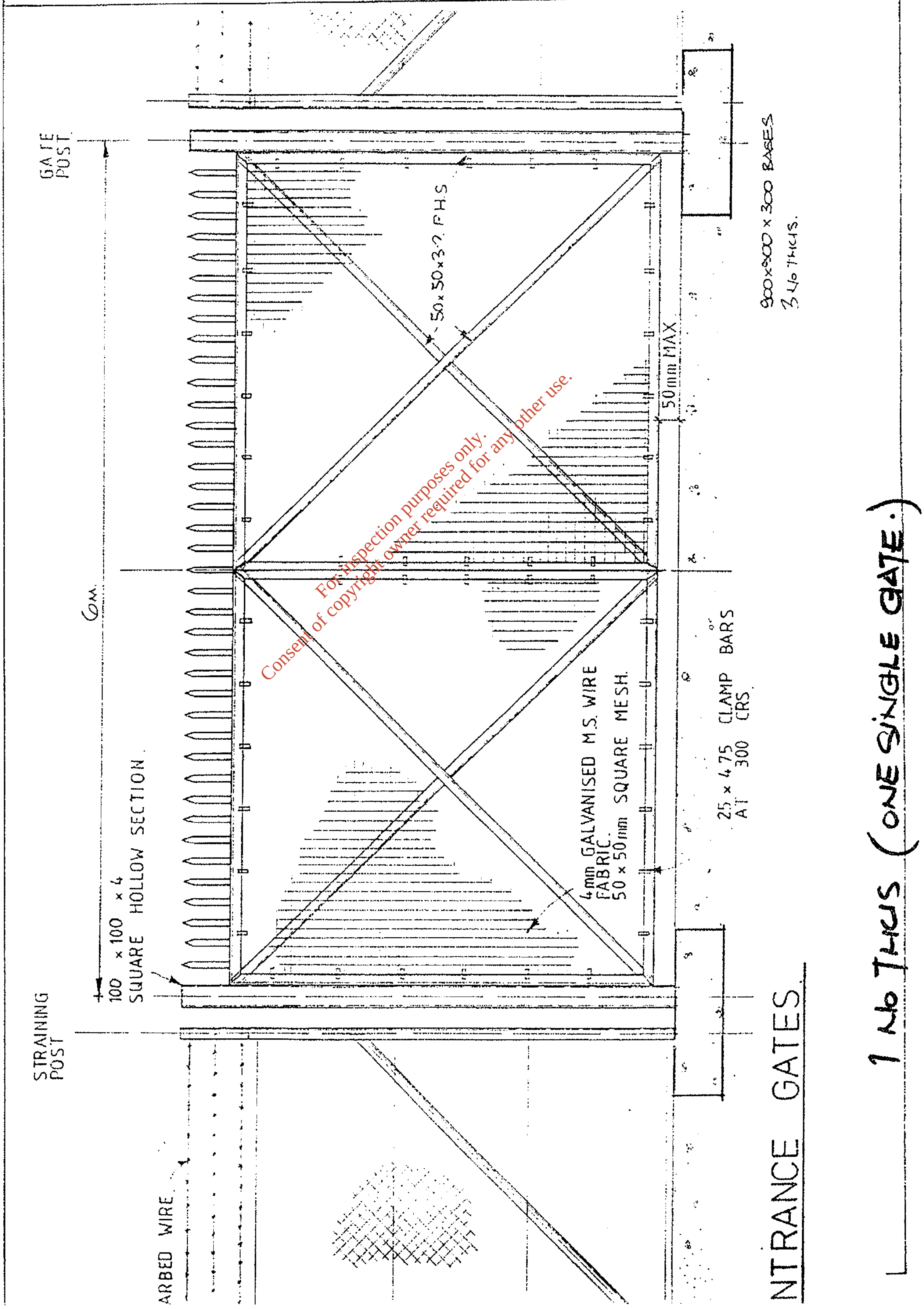
15 Custume Place, Athlone.
Tel: (0902) 74264 or 78422

job	BALLYMURTAGH OPEN PIT
job no	2170.
title	ENTRANCE GATE DETAILS
drg no	
rev	
date	APRIL 1988
by	JD.



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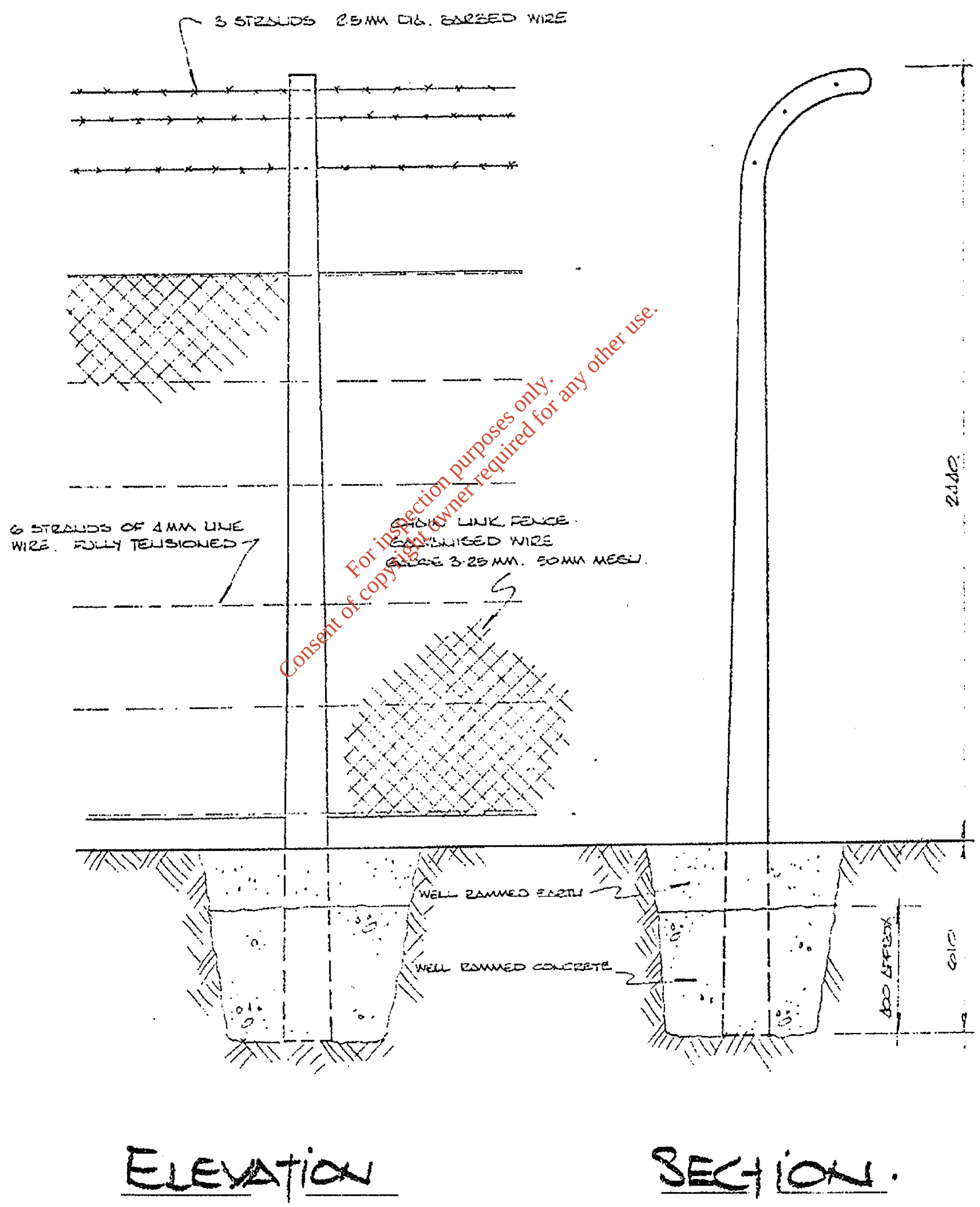
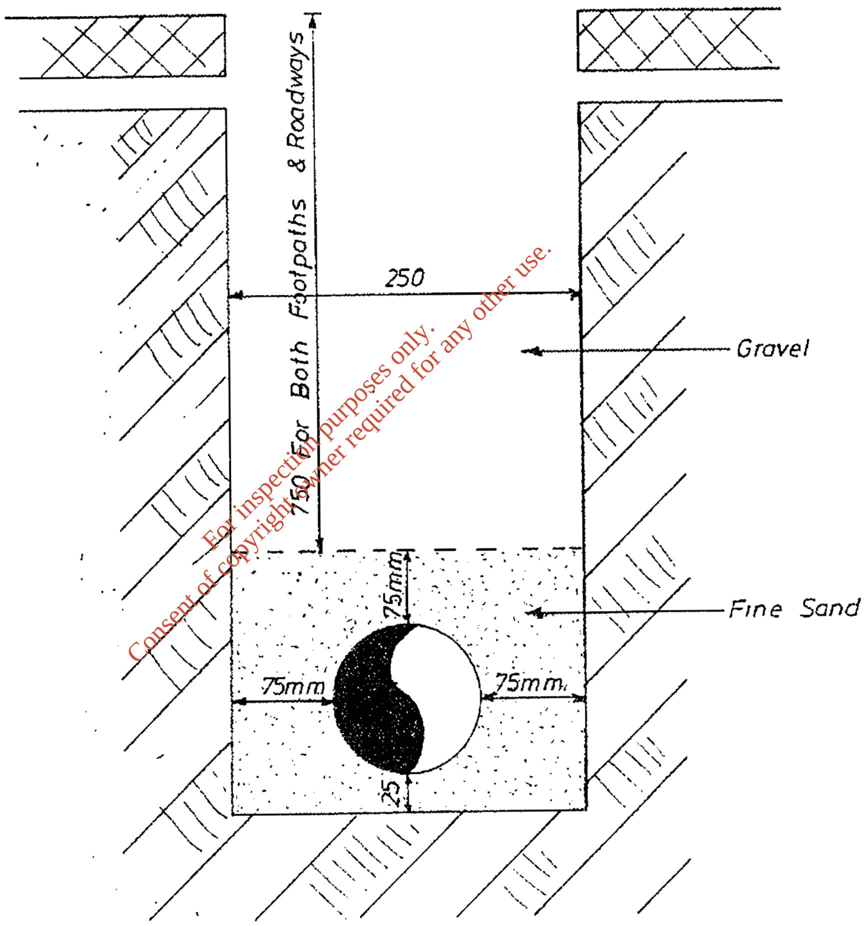
CONSULTING ENGINEERS
15 Custume Place, Athlone.
Tel: (0902) 74264 or 78422

job	title	rev	date	by	job no	drg no
BALLYMURTAGH OPEN PIT.	SECURITY FENCING DETAIL.	1/20	APRIL 1988	JL	2170	SK-5



Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel: (0902) 74264 or 78422	job: BALLYMURTAGH OPEN PIT.	job no: 2170.
	title: E.S.B. DUCT.	drg no
	rev: MTS / date: APRIL 88 / by: JD	SK:6

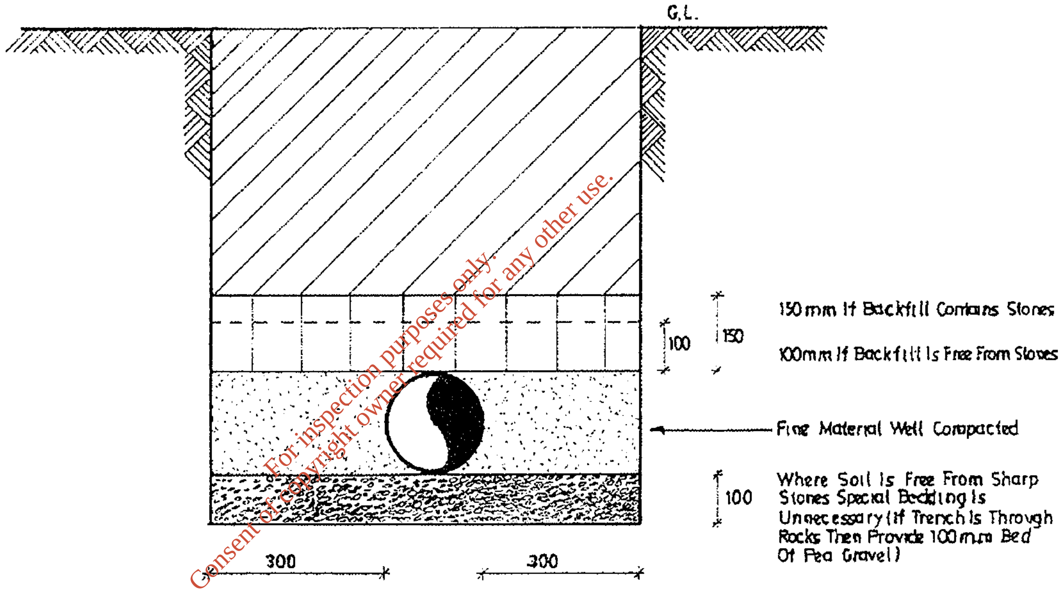


75 mm Ø Duct

UNDER GROUND E.S.B. DUCT.

JDH

Malachi Cullen Assoc. CONSULTING ENGINEERS 15 Custume Place, Athlone. Tel: (0902) 74264 or 78422	job BALLYMURTAGH OPEN PIT	job no 2170
	title WATERMAIN · BEDDING DETAILS	drg no
	rev 1 / date APRIL 1988 / by JP	SK.7.



Pipe Anchorage

Concrete Anchor Blocks Shall Be Provided On Watermains At Dead Ends, Tees, Bend Of Greater Curvature Than 22½° And At Both Sides Of A Sluice Valve Chamber. Anchor Blocks Shall Encase The Pipe In Concrete To A Minimum Thickness Of 150mm All Round And Shall Be A Minimum Length Of 600 mm