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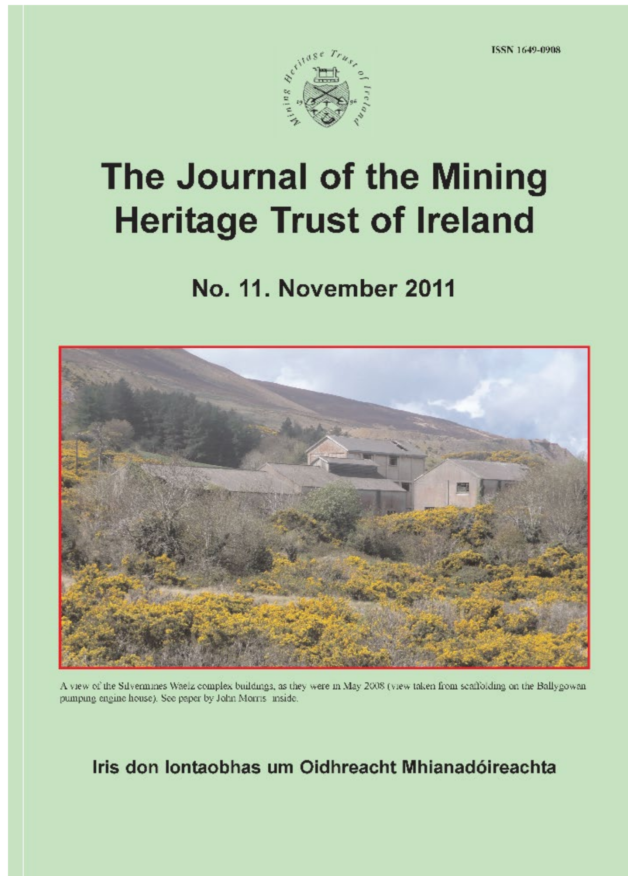

CONSERVATION OF THE 19TH CENTURY MINE HERITAGE BUILDINGS AT SILVERMINES, CO. TIPPERARY

by John Morris

Abstract: Over the four month period between April and July 2008, a total of five, 19th Century mine heritage buildings in the Silvermines-Shallee district, Co. Tipperary were consolidated and conserved for posterity in the single largest mine heritage conservation works programme ever undertaken in Ireland, the total cost of which amounted to approximately €347,000. The project was part funded by the INTERREG 3B, ATLANTIC AREA "GREEN MINES" project. This paper presents, in a format similar to previous conservation works publications, a pictorial record of the conservation works programme on the five buildings, the Shallee engine and crusher houses, the calamine building and crushing engine house at Ballygowan, and the Ballygowan pumping engine house, after introductory sections which provide an introduction to the history of mining at Silvermines and a summary of conservation efforts prior to and which contributed to the GREEN MINES initiative. The paper concludes with a brief presentation on the history of the mid-20th Century Silvermines Walz plant complex as this exemplifies a more recent form of Irish mining heritage which now, in the early 21st Century, deserves as much attention as more ancient remains.
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1. INTRODUCTION

Over the four month period between April and July 2008, a total of five, 19th Century mine heritage buildings in the Silvermines-Shallee district, Co. Tipperary were consolidated and conserved for posterity in the single largest mine heritage conservation works programme ever undertaken in Ireland, the total cost of which amounted to approximately €347,000. This remarkable achievement reflected the collaboration and cooperation of a number of public and private sector bodies, agencies and individuals, in particular:

- The Exploration and Mining Division (EMD: Loreto Farrell) of the Department of Communications, Energy and Natural Resources (DCENR);
- North Tipperary County Council (NTCC: Frank O'Halloran, Karl Cashen, Olive Dwan);
- Golder Associates, consultants retained by NTCC to manage the Silvermines area environmental remediation programme at the time (Golders: Jon Hunt, Chris Price);
- The Mining Heritage Trust of Ireland (MHTI: Martin Critchley);
- The Geological Survey of Ireland (GSI, also part of DCENR: John Morris) which acted as coordinator of the Irish partners in the INTERREG 3B, Atlantic Area funded "GREEN MINES" project under which the conservation works were part funded;
- And the local community who initiated and, to this day, continue to sustain and develop efforts to conserve the mining heritage of the Silvermines district.

This paper presents a pictorial record of the works undertaken on each of the buildings in the "before" and "after" format adopted in previous accounts of a similar nature (e.g. Morris 2002). This is prefaced first by a brief history of mining in the area up to the end of the 19th Century and then followed by a summary of actions and contributions which enabled and culminated with the commencement of the conservation works in April 2008.

2. SILVERMINES: A BRIEF HISTORY

The name Silvermines is seemingly of quite recent vintage. Boland *et al* (1992) note that it is derived from mining the residual lead-silver ores from the Ballygowan South and Knockanroe areas due south of the present day village during the 17th and 18th Centuries (Figure 1). However, mining there and in the general region is of much greater antiquity (Cowman 1988). Gleeson (1937: cited by Cowman, 1988) interprets and associates with the townland of Knockaunderrick an historical reference to Italian (Genoese) miners brought into an unspecified location in Tipperary in 1289 to open and operate a mine, which they did for the next 14 years until they were ousted by the Normans in 1303. A 1336 reference to a place name "Meianarge" (= Mine, Silver), may or may not relate to the same location, after which documentary records fall silent until 1612. Cowman (1988) provides a detailed account of the subsequent history of the mines of "Silvermines" up to 1874, from which the following summary is derived.

The reference to a "Silvermine" at an uncertain location may relate to this location, but a definitive reference to mines at Knockaunderrick is recorded in the grant of mining rights to a Messrs Whitmore and Robb in 1631. Despite their best endeavours these entrepreneurs discovered only lead and copper, rather than silver, and abandoned their enterprise in 1633, after which the rights were taken up by three knights (Hamilton, Brook, Russell) who operated the mines until 1642. They established surface infrastructure, including silver refiners and smelters to extract silver from lead ore and employed a putative 500 English men and others. The venture produced 270 tons of ore in 1641, but ended abruptly with a rebellion (a local expression of the English civil war) in 1641-2 during which a reported 14 people were killed, mainly women and children, and the English miners driven out.

Efforts were made to restart the mines during the period 1642 to 1644, and even after Cromwell's victory in 1644, but it was

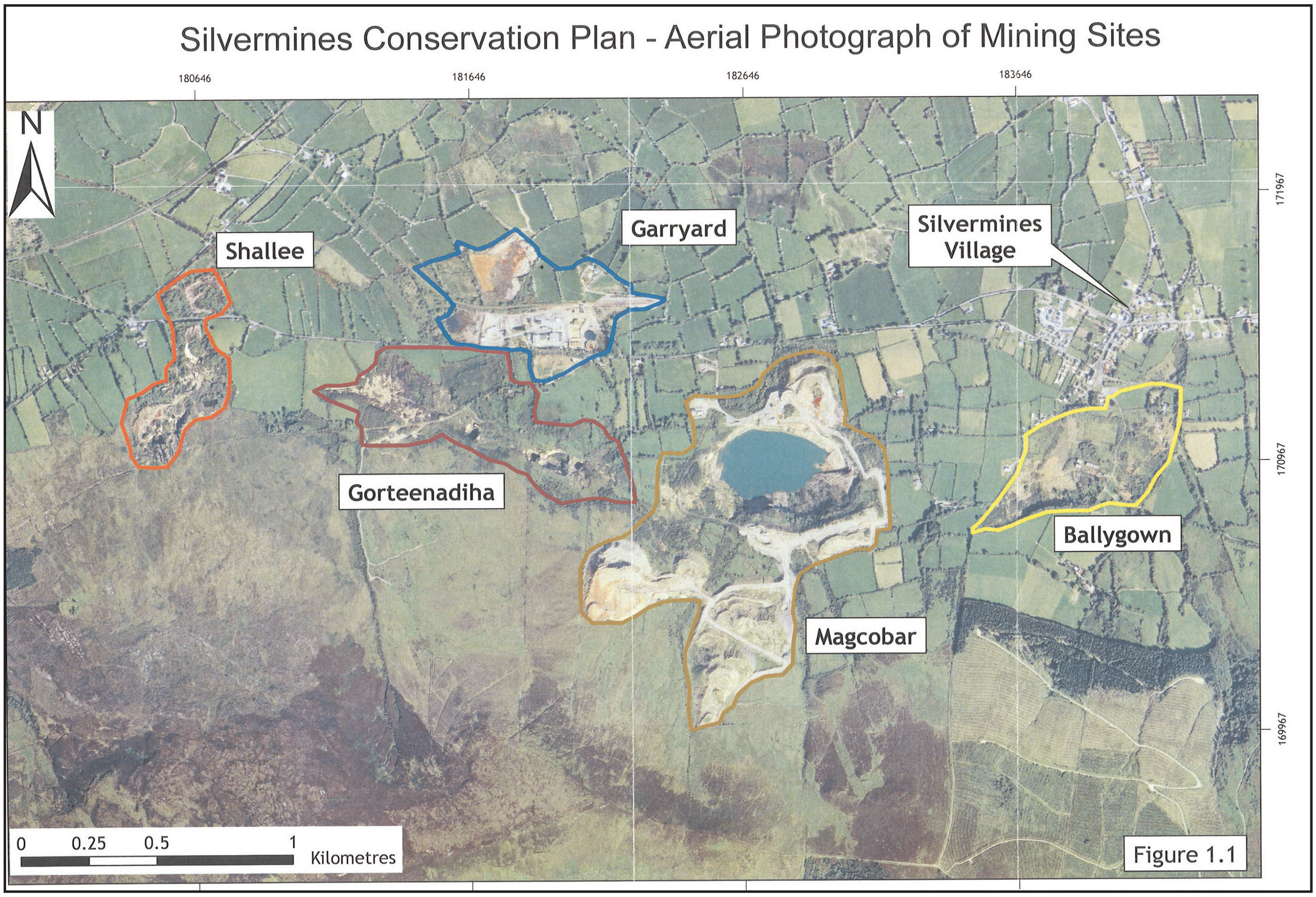


Figure 1. An annotated aerial view of the Silvermines mining district. The mine heritage features described here are located in Shallee at the western of the district, and Ballygow(a)n in the east. Other named and delimited areas represent the locations of areas of environmental remediation interest principally (Hunt 2007).

only after the re-establishment of the Monarchy in 1660 that mining activity resumed, particularly after 1680 with the introduction of coal fired reverbatory furnace technology. That effort was truncated by a combination of the Jacobite War and protracted legal proceedings to establish land ownership, and thereby control of mineral rights, which were eventually resolved by a judgement in favour of Colonel Henry Prittie in 1701. These legal proceedings appear to have served as a test case to establish Crown ownership of silver in the United Kingdom, an aspect now under active research by D. Cowman who has kindly provided the following précis (D.Cowman, pers. comm, 2011).

> " In theory all precious belonged to the Crown which gave Royal Permission to favoured people to work silver and gold mines. In 1630 such a one was Sir George Hamilton (son of the Duke of Abercorn) who obtained the rights to Silvermines. Even after the huge disruptions over the period 1640 to 1650, George Hamilton emerged with rights intact after the restoration of the monarchy. Land ownership had changed, however, the native Kennedy's being replaced by the Cromwellian planter, Henry Prittie. The death in quick succession of George Hamilton and his son meant that the Royal mineral rights at Silvermines passed to James Hamilton, still a child. Prittie apparently availed of this to start to work the mines himself about 1680. The Jacobite War 1689 to 1691 temporarily disrupted this but the now adult James Hamilton reasserted the family entitlement. Prittie's challenge to this was probably based on the argument that the silver was exhausted and it was now only a lead mine. At any rate, over a number of court cases between 1700 to 1703, Prittie emerged victorious though it took an Act of Parliament to grant his rights as a landowner thereby setting a precedent in law. James Hamilton, now the Duke of Abercorn, was compensated with £4,000 for his loss - more than the mine ever made over the next hundred years. This effectively ended the Royal prerogative over silver though it continued to be exercised for gold. The Prittie's never tried to work Silvermines themselves again, but they now had the right to lease it to others."

That should have cleared the way from resumption of mining activities but, instead, much of the activities during the 18th Century centred around efforts by Prittie and his successors to lease the mining rights to a succession of other parties, possibly because all of the easily worked surface and near surface ore had been extracted during previous operations.

Desultory efforts were undertaken by various operators between 1707 and 1724, during which period copper was discovered, and again between 1724 and 1734, by the very cumbersomely entitled "**COMPANY FOR SMELTING DOWN**

LEAD WITH PIT COAL AND SEA COAL", a subsidiary of the **LONDON LEAD COMPANY** (Des Cowman, pers. comm, 2011). Mid-18th Century references note efforts by two individuals to develop mines in the district, one from 1758 (Martin O'Connor), the other (Thomas Sadlier of Nenagh) over an unspecified period. The latter enterprise appears to have mined lead from two locations, at "Knockeen" and particularly from what was described as a new discovery at "Keevestown" (= Shallee?: Cowman, 1988), from which 200 to 300 hundred tons of lead ore was extracted. Copper ore was produced also, and apparently discarded, although 90 tons of copper ore and 5 tons of lead ore were produced in 1770.

By 1792 Shallee was described as a "very productive" endeavour. A rich zone of lead ore had been discovered, as well as pure silver; a smelter constructed to produce lead sheet and shot; and dividends of £300 per annum paid to each of the four principal shareholders (two Tydd's, Harding and Whyte) in the unnamed mining enterprise. Silver plate was apparently fabricated for the Dunally family from the silver production, as was a very fine soup tureen crafted by Joseph Robinson, silversmith, c.1760 which bears the inscription "The gift of the Silvermines Company to Quintin Dick Esq for the many compliments they received from him" (D. Cowman, per. Comm., 2011). Who Dick was and what the nature of the matters were which prompted such a gift is presently unknown, although there is a suggestion that he may have been a Nenagh based hotelier. Overall the enterprise appears to have continued successfully until the death of the mine manager, Captain Hall, in the late 1790s.

By about 1800 all operations had ceased once again, but in January of that year, Henry Sadlier Prittie, owner of the lands and mineral rights, was created the first Lord Dunally. He died in 1801and was succeeded by his son, who leased the mining rights to a Cornelius Bolton, previously involved with lead mining in Co. Waterford, and they, together with Bolton's mining business colleague, Col. Robert Hall, and various Dunally relatives, formed the **DUNALLY MINING COMPANY** (1802 - 1805). Cowman (1988) provides a detailed analysis of the shareholders in this company and describes its initially benevolent intent towards its employees, their wages and conditions, while noting that little was recorded about its mining activities. It seems to have been under-capitalised from the outset, and never achieved its funding targets. Debts, for wages and materials, as well as expensive trials, accumulated rapidly, even though some copper ore was raised and sold in mid-1803, but all operations appear to have ceased by September 1803. Copper ore was produced also in mid-1803 from a separate operations at Knockeen (= Gortadina?: Cowman, 1988).

Mining activity essentially ceased for the next 30 years after the collapse of the Dunally company, apart from a passing assessment by the **HIBERNIAN MINING COMPANY** and the **IMPERIAL MINING COMPANY**, two of four joint stock companies established by Act of Parliament in 1824. The HMC assessed but quickly abandoned an interest in Shallee while the IMC invested in ultimately fruitless trials across other parts of the district.

Further interest languished until gold was discovered on the far side of Knockaunderrick in the mid-1830s. This discovery attracted the interest of mining promoter John Salmon, previously involved with mining ventures in Co. Wicklow. He, with a degree of misrepresentation concerning his relationship with the reputable London firm of John Taylor, attempted to negotiate leases from both Lord Dunally and Donatus O'Brien, lease owner of the Shallee deposit. His efforts became embroiled in litigation, finally resolved with him losing all actions in 1844. One of the early victors, John Taylor, undertook some exploration work in 1839, but sold the lease to the **MINING COMPANY OF IRELAND** (another of the 1824 Act of Parliament companies) in 1840 for £853. Over the next there years the MCI assessed the sulphur and lead production potential of the Gortadina and Ballygown mineral deposits, before abandoning their interests in 1844. This created the opportunity to once again attempt to combine all the mining leases, along with Lackamore, in to a single operational enterprise, achieved with the establishment of the **GENERAL MINING COMPANY FOR IRELAND** (GMCI) in 1845 (Table 1). This company dominated mining activities at Silvermines for the next 30 years, and all of the extant 19th Century mining heritage features, the subject of the conservation work undertaken in 2008, derive from the activities and operations of that company.

That however proved to be the apogee of company success: from then onward its fortunes began to wane and exposed deficiencies in decisions not to re-invest profits during its productive years. This included a failure to invest in steam powered pumping engines, even as mine workings reached ever greater depths and the limits of water wheel powered pumps. Further trouble accumulated through the failure to pay miners wages, mounting operational losses and inadequate accounting procedures, all off set to a degree by making "calls" on shareholders which, by 1858, amounted to £2-7-6.

In January 1859, the GMCI announced the discovery of zinc in the gossan (Brown 2003) at *Garryard* and with it the hope that this, along with potential value of sulphur sales, would be the salvation of the company. Over the next two years, exploration efforts defined a deposit ranging between 10 to 60 feet in thickness underlying an area several acres in extent. At the same time the company sent an engineer to Belgium to observe how the ore might be processed (Brown 2003). Production commenced in 1860, when 890 tons of zinc ore, worth £1,160, was produced and sold in 1860, and thereafter zinc continued to be produced up to the last recorded production in 1874 (Table 2). The value of this production increased quite rapidly up to a peak of £10,216 in 1863, although the company augmented its finances over this period by selling further shares, amongst other means. In 1866 it announced plans to construct an eleven furnace complex in order to enhance the value of the end product to the company (the Calamine Building: see below. Brown, 2003 notes a cost of £184 for the engine house and calciners), only to discover over the next five years that there was little market demand for the product. Over the period 1860 - 1874, the company produced 16,751 tons of zinc ore, with an aggregate value of £42,260 principally in the period between 1860 and 1865 and it is likely that this very productive period led the company to make the fateful decision in 1866 to construct the calamine building (see discussion section 8 below also).

DATE	Notes	Share sales	Income (£)	Expenditure (£)	Dividends
1845 October 7	Company formed. Offices: 43, Lower Sackville Street, Dublin.				
	Capital: 25,000 shares of £25; initial deposit £1.				
	Committee: Thomas Wyes; Sir James Murray (Doctor); Henry and Abraham Abraham (Goldsmiths, Southampton); Pierce Nagle Esq. (Doneraile, Co. Cork); Finley Cusack (Barrister, Dublin); Thomas Quintus, Esq (Dublin); Francis White (Doctor and Inspector General of Prisons); William Wilton, Esq (Dublin); Daniel Brady (Doctor, Dublin).				
1846 February 17	Final registration.				
	Shareholders: mainly Dublin resident. 2/6 deposit paid on most shares	805	c. 100		
June 15	Credit balance		927-15-0		
	Expenditure includes £100 given to Maguire (Co. Secretary) to investigate Shallee			407-12-0	
	New offices: 2, Burgh Quay, Dublin				
October 5	Call on shares + share sales late 1846	150	1,475-12-6		
	Work at Shallee (£709) and Lackamore			984-13-9	
1847 Apri7 6	Disbursements to Capt. Curry for works at Silvermines, Lackamore and Shallee			c. 1,500	
	Ore sales lead (£1325) and copper		1965		
	Purchase of Lackamore and machinery			1,000	
August 27	Shares forfeited (including both Abraham's) and bought by a Director				
Oct. 6	Mining "disbursements"			2095	
	Ore sales: lead (£1,721), copper and pyrite (£6)		2,417		
	Further calls on shares and sale of forfeited shares				
1848 January 10	Share purchases by Caroline and Robert Maguire, at office address				
April 3	Mining disbursements			2,703	
	Lackamore purchase			1,000	
	Ore sales: lead (£2,468) and copper (£393)		2,861		
	Credit balance: £2,605				
October 2	Mining disbursements: Shallee (east and west: £1,722) and Lackamore			3,200	
	Ore sales: Lead (Shallee E, £2,056; Shallee W, £105), copper Lackamore, £448)		2,609		
1849 April 2	Ore sales: lead (£1,500), copper £148 (Lackamore)		1,648		
October 1	Ore sales: lead (£2,484), copper £549 (Lackamore)		3,033		
	Mining disbursements include activities at Gortnadyne and Garryard				
1850 April 1	Ore sales: Shallee (£3,224), Lackamore (£553) and Gortnadyne		3,960		
	Mining disbursements include activities at Ballynoe and Ballyhourigan				
	First dividend				5%
October 7	Ore sales: Shallee (lead £4,046 + copper, £73), Lackamore (£853), Gortnadyne (£1,140), Ballynoe (£231)		6,143		
	Dividend				5%
1851 April 9	Ore sales: Shallee E (£3,408), Shallee W (£157 + copper, £73), Lackamore (£208), Gortnadyne (copper, £1,566), Ballynoe (£552)		5,891		
	Dividend				10% (total £603-13-9)
October 6	Ore sales: Shallee (lead, £3,386), Lackamore (copper, £603), Gortnadyne (£2,090), Ballynoe (£8), Nickeen (£55)		6,142		
	Mining disbursements include activities at Nickeen and Aughavaher				
	Shallee royalty purchase			250	
	Dividend				10% (total £603-13-7)
1852 April 7	Ore sales: Shallee (lead, £2,588), Lackamore (copper, £458), Gortnadyne (£1,626)		4,672		
	Dividend				10%
	Credit balance: £1,484				
October 12	Ore sales: Shallee (E only, lead, £3,825), Lackamore (£443), Gortnadyne (£1,814)		6,082		
	Dividend				5%

Table 1. A summary of GMCI financial, shareholder and management records which form part of the Company Records Office archives conserved in the Public Records Office, Kew, London: file reference BT41/253/1441 (Morris and Cowman, 2001). The value of ore sold is the aggregate value of all sales; values for specific sites are included in the notes.

YEAR	ORE TYPE	BALLINOE		GORTEEN ADIHA		KNOCKAN ROE		LACKAMORE		SHALLEE (inc. WEST)		SHALLEE EAST		SILVERMINES	
		Ore	Value	Ore	Value	Ore	Value	Ore	Value	Ore	Value	Ore	Value	Ore	Value
1806	Cu							40							
1807	Cu							76							
1828	Cu							17							
1837	Cu							19							
1838	Cu							143							
1839	Cu							407							
1840	Cu							510							
1841	Cu							648							
1842	Cu							411							
1843	Cu							260							
1844	Cu							166							
1845	Cu							119							
1846	Cu							124							
1847	Cu							69							
	Pb									209					
1848	Cu							152	1164						
	Pb									340					
1849	Cu							114	745						
	Pb									329					
1850	Cu	59	521	154	1240			101	863						
	Pb									473					
1851	Cu	97	542					204	1218						
	Pb									465					
1852	Cu							140	794						
	Pb			76						287		433			
	Ag (ozs)			300						12000					
1853	Pb			220						282					
	Ag (ozs)			3280						7020					
1854	Cu							159	1424						
	Pb			214						142					
	Ag (ozs)			2900						3420					
1855	Pb			100						28					
	Ag (ozs)			1593						600					
1856	Pb			311											
	Ag (ozs)			470											
1857	Cu	15		130											
	Pb			51								112			
	Ag (ozs)			76								167			
1858	Cu	37		42				53	537						
	Pb			16								69			
	Ag (ozs)			23								1584			
	Pyrite					534	450								

YEAR	ORE TYPE	BALLINOE		GORTEEN ADIHA		KNOCKAN ROE		LACKAMORE		SHALLEE (inc. WEST)		SHALLEE EAST		SILVERMINES	
		Ore	Value	Ore	Value	Ore	Value	Ore	Value	Ore	Value	Ore	Value	Ore	Value
1859	Cu	104		55				64	496						
	Pb			16						24					
	Ag (ozs)									360					
	Pyrite					344	170								
1860	Cu	10													
	Pb			15											
	Ag (ozs)														
	Zn													540	1160
1861	Cu			42											
	Pb									91					
	Zn													890	1780
1862	Pb									67					
	Zn													1597	4192
1863	Pb									60					
	Ag (ozs)									165					
	Zn													3892	10216
1864	Pb									159					
	Ag (ozs)									3746					
	Zn													3500	9215
1865	Pb									40		110		11	
	Ag (ozs)									830		4360			
	Zn													4040	8140
1866	Pb									122		63		2	
	Ag (ozs)									3145		3490			
	Zn													677	1354
1867	Pb											84			
	Zn													132	429
1868	Pb									128		80		40	
	Ag (ozs)													1111	
	Zn													79	246
1869	Pb											158			
	Ag (ozs)											5480			
	Zn													64	192
1870	Pb											80			
	Ag (ozs)											2815			
	Zn													312	937
1871	Pb									30					
	Zn													321	964
1872	Pb									37					
	Ag (ozs)									1040					
	Zn													605	1906
1873	Zn													234	1889
1874	Pb									4	71				
	Zn													1	3

Table 2. Summary of copper (Cu), lead (Pb), silver (Ag) and zinc (Zn) production of Silvermines district mines, 1804 - 1874 (simplified from Morris, Cowman* et al.*, in prep.). All production figures, except silver, are in tons and are for ore (not metal content). All values in pounds (£).

By 1870 the company's finances were in such a parlous state that it decided to establish a subsidiary company to operate *Shallee* and *Gortadina*, the **SHALLEE SILVER LEAD MINING COMPANY**, with the objective of raising £30,000 capital, half of which was to be paid to GMCI. This stratagem failed, and even though it struggled on during 1872, the end was in sight by mid-1873. By then the boiler of the zinc mine pumping engine (Ballygowan South: see section 9 below) had burst; the zinc mine flooded; and the furnaces lay idle and unused. A cheque for £1,000 received from the subsidiary Shallee Silver Lead Mining Company proved to be worthless, and the company was put into liquidation subsequently.

Thereafter, in the period up to 1914, various efforts of limited scope and extent were undertaken on various parts of the Silvermines district (Morris, Cowman et.al, in preparation). The **HIBERNIAN DEVELOPMENT Co. Ltd**., of 29, Cornhill, London undertook surface and underground operations at Gurtnadyne/Gorteenadiha and at Silvermines between 1902 - 1906, under the management of an Alfred Wright 1900-1902 and August S. Birch between 1903 -1906. The Silvermines operation passed into the ownership of the **IRISH ZINC, LEAD, SILVER MINES Ltd**, of Silvermines Co. Tipperary in 1909, under the management of R.O.Ahlers. Shallee (East) continued in the ownership of the **SHALLEE SILVER LEAD MINING COMPANY** up to 1877, thereafter passing into the ownership of a Charles Cummins up to 1881.

No further mining or exploration activities were undertaken in the subsequent period up to the time of the First World War (1914-1918), after which the mining properties again lay dormant until they were acquired by the **BRITISH (NON-FERROUS) MINING CORPORATION LIMITED** (BNFMC) in 1931 (Griffith 1955: see below also). That company undertook an integrated programme of drilling and underground development, principally on the calamine deposits. It included six bore holes, the best of which intersected calamine zones grading between 7% to 11% over thicknesses up to 37 feet (c. 11m), and underground developments, most extensively from the "Twin Shafts" which is located about 450 feet (c. 137m) south southwest of the Ballygowan engine house (see section 9 below). The shaft was cleaned out to a water table depth of 124 feet (c. 38m), 1,600 feet (c. 488m) of drifts completed, and a long drainage adit constructed. The company estimated calamine ore grades of about 21.4% zinc above water level in this shaft; an overall ore resource of about 500,000 tons; and an additional 15,000 tons of material ranging between 15% to 22% zinc and up 0.86 ounces (c.24 grams) of silver/ton in nine large spoil heaps generated by previous operations (Griffith 1955). In 1934, a large bulk sample of calamine ore was shipped to the Krupp's laboratories in Magdeburg, Germany for trial processing using the Waelz method (Griffith 1955). The ore used in this trial production averaged 22% zinc and 1.88% lead, while the end product zinc oxide concentrate graded 70% zinc and 4% lead.

Nothing further happened until after the Second World War when all of the Silvermines-Shallee properties were acquired by the **SILVERMINES LEAD and ZINC COMPANY LTD** in 1948. This company focussed its efforts upon developing the calamine ore resources at Silvermines and lead at Shallee, although more limited exploration was also undertaken at Knockanroe (including underground development) and Gortnadyne (Griffith 1955). At Silvermines, the company undertook:

- a significant surface and underground exploration programme to better define and increase the calamine ore resource;
- initiated surface open pit and underground mining operations, the latter via a new shaft, the Russell Shaft, in the area immediately south of the Ballygowan Engine House (section 9 below);
- and in 1950 built the Wälz/Waelz complex to process the calamine ore. This complex is described in more detail in Section 10 below.

At Shallee, the company undertook an equally intense level of works to establish and operate mining and processing facilities (Griffith 1955). This included:

- cleaning out and rehabilitating for use four of the five shafts developed during previous operations, the Barry, Whim, King and Engine shafts. The remaining Field Shaft, albeit the principal production shaft in previous operations, was too badly caved to be suitable for re-use. Most underground development centred upon the Whim shaft and while the Engine shaft was also prepared for such use it had to be abandoned due to flooding problems;
- Moderately extensive diamond drilling from surface in the vicinity of the Whim and Engine shafts;
- Development of open pit mining operations at the "Rich Quarry" adjoining Engine Shaft;
- Erection of head frames; adaptation of the old 19th Century Shallee Engine house to serve as on ore bin (see Section 5 below) and construction of various ancillary facilities, including conveyor belt systems, a compressor house and an assay laboratory;
- And refurbishment of the 200 ton/day ore mill facility established during previous operations. Up to November 1951, the mill was unable to process more than 100 tons/day although subsequent modifications increased capacity to about 170 tons/day by May 1952.

Between April 1950 and July 1951, the company produced and processed 9,657 tons of ore at Shallee, equivalent to 21.4 tons/drill shift (Griffith 1955). A significantly higher level of production is recorded for the period between April 1951 and March 1952, during which time 33,539 tons of ore at an average grade of 1.95% lead was mined and a total of 696 tons of lead concentrate grading 60% lead was produced. Mining costs during that latter period (1951-1952) amounted to £23,358 while milling costs totalled £29,027 (Griffith 1955). At Silvermines, the company processed a total of 7,081 tons of calamine ore with an average grade of 13.9% zinc and 1.74% lead and from this produced 790 tons of zinc oxide concentrate at an average grade of 59.04% zinc and 7.54% lead (Griffith 1955). Due to poor metal prices, all production ceased at Silvermines in October 1952 and at Shallee in April 1953, even though work was in progress at that time to increase mill capacity to 10,000 tons/month, and eventually to 20,000 tons/month.

3. CONSERVATION WORKS: PREPARING A WAY FORWARD

The conservation works programme reflected the timely convergence of a variety of actions and endeavours undertaken by not only those bodies listed in the introduction above, but also by a number of other bodies and individuals over many years prior to 2008. In particular, the protracted commitment and determination of MHTI founder member Eamonn de Staffort of Silvermines to achieve the conservation and development of the mine heritage of the area provided the key driving force behind what was ultimately achieved in 2008.

Although his interest in the mining heritage of Silvermines is of very long standing, the defining moment came with his organisation of a landmark seminar on the mining history and heritage of the area in Nenagh, Co. Tipperary in June 1989 - a date chosen specifically to celebrate the 700th anniversary of the first documentary evidence of mining in the area (de Staffort 2003: see above also). That enormously successful event, opened formally by Mr. Michael Smith, T.D., Minister for Energy, stimulated a huge groundswell of local support and enthusiasm for heritage development. This encouraged local and regional bodies to undertake several mine heritage development feasibility studies, including one by Brady, Shipman and Martin in 1992 and a later analysis prepared by Stevens and Associates for Shannon Development in 1996. The latter study presents an analysis of the tourism potential and value to the region of developing Shallee ("Shallee Silver Mine") as a national tourist attraction. It includes (NB. All monetary figures in Irish £, where IR£ = Euro 1.27):

- a summary inventory of extant surface mine heritage features and especially accessible underground workings which are considered a critical part of the tourism development concept
- a concept for a complementary surface only "discovery trail"
- the proposed development of a range of other facilities including interactive science and educational displays, a gift shop and tea rooms, centred primarily on the King house, the 19th Century ex-mine managers house (at Shallee, Figure 1).
- an analysis of various market groups, tourism, local and educational, from which target visitor numbers were projected, ranging from 40,000 in year 1 to 55,000 by year 5, providing a gross income from entrance fees rising from IR£106,600 in year 1 to £229,150 by year 5.
- a proposed two phase development over the 5 year period, at a total overall capital cost of £550,700. This includes a provision for conserving and fitting out the King House and its immediately associated buildings as a visitor centre, at a total projected cost of c. £228,000.
- an estimate of gross revenues (including gift and catering sales, as well as admission ticket sales) were projected to rise from £144,600 in year 1 to £327,450 in year 5, while total operating costs were projected to rise from £218,000 in year 1 to £254,000 in year 5, with operating break even occurring in year 3 and cumulative break even in year 5.

In September 1998 Mr. Smith, by then Minister for Defence, announced an award of £1,000,000 towards the cost of development of a "National Mining Heritage Centre" in Shallee (de Staffort 2003) , a pledge reiterated at the opening of a "MINET" mining heritage conference in Nenagh in November 1999 (Morris and Parkes 2003: see below also).

MINET was a pilot European mining heritage network established in 1999 with EU financial support to explore and develop understanding of mining heritage centres in various parts of Europe and move towards creation of an association of such enterprises. That initial effort was sustained, with financial support from the EU Culture 2000 programme, through the creation of the "EUROPAMINES" mining heritage network in the period up to 2006, the same year during which the Diputación de Huelva, Spain conceived a new approach to mine heritage conservation and development within a concept they labelled "GREEN MINES". That concept sought to develop conservation in conjunction with environmental remediation and concomitant development of tourism and other related economic activities as a framework to achieve economic and social revitalisation of post-mining communities.

Over the same period between 1999 and 2006, the focus of interest in the Silvermines area shifted increasingly towards environmental remediation to mitigate deleterious impacts of mining waste upon water and land, and inter-related health concerns (Figure 1). The Government established a fund of some c. Euro 10.6M to progress the remediation works and fund mining heritage works, albeit the latter at a significantly lower level than that indicated in 1998. The resulting combination, remediation and conservation, aligned very well with that of the "GREEN MINES" concept, and facilitated NTCC, GSI and MHTI to accept in early 2006 an invitation from the Diputación de Huelva to participate in the development of an INTERREG 3B, Atlantic Area GREEN MINES project. That invitation was extended to other prospective partners in the Atlantic Area and by mid-2006, when the application was lodged, the consortium also included ADRAL (Portugal, on behalf of the municipalities of Mertola, Aljustrel, Grandola and Castro Verde) and Blaenau-Gwent County Borough Council and Cadwyn Clywyd (Wales, UK).

The 18 month project was approved for funding in January 2007 and commenced with an inauguration meeting of all partners in Huelva in May 2007. The total Silvermines component of the overall project budget as submitted and approved was Euro 379,623, of which Euro 150,000 was allocated to conservation works specifically. That provision was intended to be additional to that committed in the Government funding, but it had to be increased significantly within the project budget envelope due to escalating national budgetary constraints during the latter part of 2007 which reduced significantly the amount allocated to conservation works. A revised "GREEN MINES" project conservation works budget of Euro 316,323 was developed in early November 2007 by reducing and/or abandoning various other actions contained in the original application, and sanction sought from the INTERREG Secretariat through the Lead Partner, Diputación de Huelva, to make the proposed budgetary adjustments: approval to so do was granted in December 2007.

The uncertainties surrounding the conservation works budget precluded initiation of any substantial level of works throughout 2007, although various preparatory actions were undertaken in order that the works could commence immediately all administrative problems had been overcome. These works included:

- preparation by Golder Associates Ireland of an unpublished report on the conservation priority of various buildings (Hunt 2007). This expanded upon another unpublished report prepared for NTCC in 2006 by the Mining Heritage Trust of Ireland (MHTI 2006);
- preparation of detailed plans and elevation surveys of each building;
- preparation of conservation works tender specifications and documentation;
- completion of a bat survey (Aughney 2007);
- and trimming back ivy overgrowth on various buildings in late 2007, in conformity with bat protection restrictions (Aughney 2007).

Golders staff played a critical role in preparing and managing a number of the various preparatory actions, and they in conjunction with NTCC managed tender advertising in conformity with EU tendering procedures and award of the works contract once all problems had been resolved. The works tenders were advertised in late 2007 and ultimately awarded to InterClean Limited in mid-April 2008 (Newspaper article, "The Nenagh Guardian", April 19, 2008). This announcement coincided with a major international mining heritage conference, opened formally by Minster of State Tony Killeen, T.D., which was convened under the auspices of the GREEN MINES project and held in Nenagh between April 21 - 23, 2008. It had been anticipated originally that this conference would coincide with the completion of the conservation works programme and launch of the conserved buildings as a local and regional tourism asset: instead it coincided with the commencement of the works programme.

4. "GREEN MINES" CONSERVATION WORKS

The various tourism development initiatives and mine heritage reports identified a range of natural, archaeological and built heritage features the conservation of which were considered vital to the development of a viable tourism attraction. The needs to conserve and protect the natural and archaeological features were largely accommodated by NTCC within the evolving environmental remediation programme, while conservation of the built heritage features was assigned primarily to the GREEN MINES [GM] project. However, its capacity to meet this objective was circumscribed by various constraints:

- the budget capacity available within both the GM budget and the environmental remediation programmes, as noted above;
- the proposed demolition of the entire early 1950s Wälz/Waelz plant complex on health and safety grounds (see section 10 below);
- and the exclusion of the King House and adjoining buildings, the proposed site of the "Shallee Silver Mine" visitor centre, as these were all subject to a protracted receivership process.

The Green Mines conservation efforts were consequently constrained to the range of 19th Century mine heritage buildings, and even for these, budgetary constraints required that the works programme had to be prioritised, although all were ultimately consolidated. The order of conservation priority was as follows (see Figure 1 for locations):

1. Shallee Engine and Crusher houses - the only extant steam powered crusher house left in Ireland and one of very few double beam engine houses (to operate crushing and stamps functions to the front, and possibly flat rods to a pumping installation to the rear);
2. Calamine building and Crusher Engine House (Ballygowan) - the only such 19thC zinc oxide roasting facility in Ireland, constructed in 1866 and operational up to 1873.
3. Ballygowan (South) Engine house

5. SHALLEE ENGINE HOUSE [Figures 2-11]

Brown (2003) provides a very brief analysis of this engine house although its exact date of construction is unknown. Cowman (1988) makes passing mention of the purchase of two steam engines sometime after 1853, one for pumping and one for crushing (presumably the Gurtnadyne/Ballygowan Crushing Engine: see below), and notes the collapse of a newly constructed engine house at an unspecified location in 1855. Brown (ibid) surmises that the Shallee Engine House was constructed at some time in the late 1860s most probably to replace a 50 foot waterwheel. He deduces, from the presence of two sets of crank bearings on either side of the flywheel pit on the north side of the building, that it served a dual function: to power the crushing machinery in the adjoining Crusher House and possibly to power, through a set of flat rods, a pumping installation in an "Engine Shaft" located to the south east of the engine house. The engine itself may have been double acting, although Brown (ibid) cautions that this interpretation needs to be confirmed by the identification of trunnion anchor bolts in the bob wall.

Part of Brown's (2003) analysis is confirmed by the appearance of the building and its associated surface installations as they appear in several historical photographs of this building reproduced by Hodnett (2007). The earliest of these date from 1937 and show the still, at that time, remarkably intact engine and crusher houses, with roofs largely intact and the engine house bob, sweep arm and double flywheel all in situ (and presumably the engine inside the house: Figure 2). The depictions confirm that the engine powered the crusher house installation, as Brown (2003) suggests, but not flat rods on the opposite side. Instead that drive shaft powered a set of "stamps", of which part of the eccentric crank with lifters is visible close to ground level; several individual stamps, one lying across the eccentric crank; and what appears to be a surviving wooden upright of the stamps frame (Hodnett 2007: Figure 2).

During the course of ivy trimming and cutting back of other vegetation preliminary to the commencement of conservation works in 2008, Martin Critchley (pers. comm. 2007) observed that the rear (south) wall of the engine house possibly served as a "bob wall" for a rearward facing "bob" or "beam" which may have powered the pumps in the engine shaft further to the south via a run of flat rods (Figs. 3, 4). This interpretation is based upon the thickness of the wall as well as the form of the deep slot in the wall which mimics that in the front (north) bob wall.

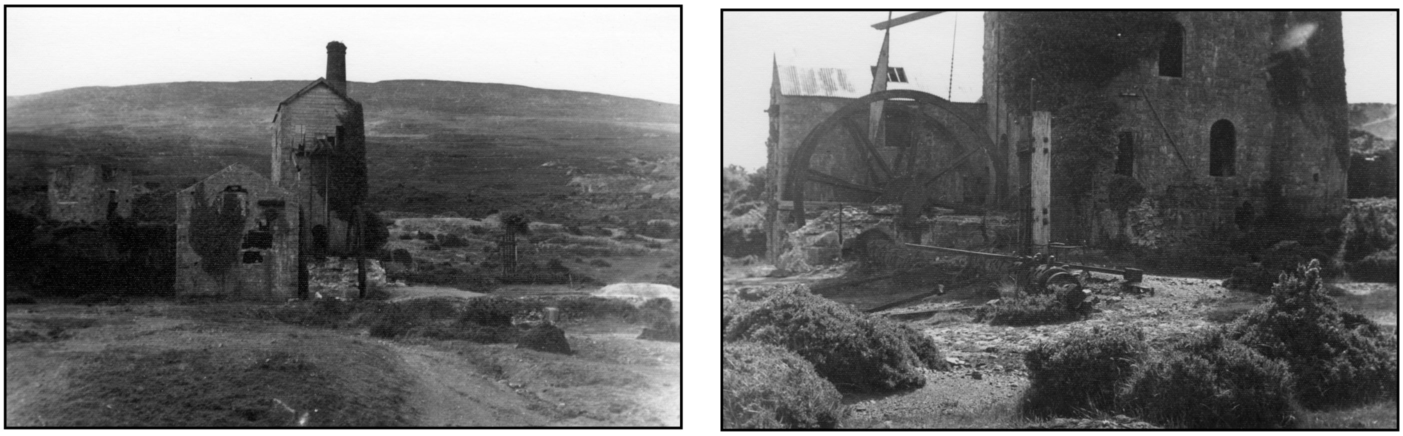


Figure 2. Shallee engine and crusher houses, 1937. The relatively intact state of both houses, including woodwork, external machinery and at least the roof of the crusher house, is quite remarkable as the buildings had lain derelict for over 60 years after recorded operations had ceased at this site in 1873. On the engine house, note the in situ weather boards in the bob wall slot, the bob, sweep arm, double flywheel and ivy covered stump of the boiler house lean to wall (left image); and the absence of a slot at the base of the southwest wing wall (right image). To the right of the flywheels, note the remains of a stamps installation and, to the left, the crusher engine house and to its left, and at a slightly higher level, the roofless remains of a building of similar design to the crusher house (left image). Both images reproduced from Hodnett (2007), originals copyright Royal Institution of Cornwall.

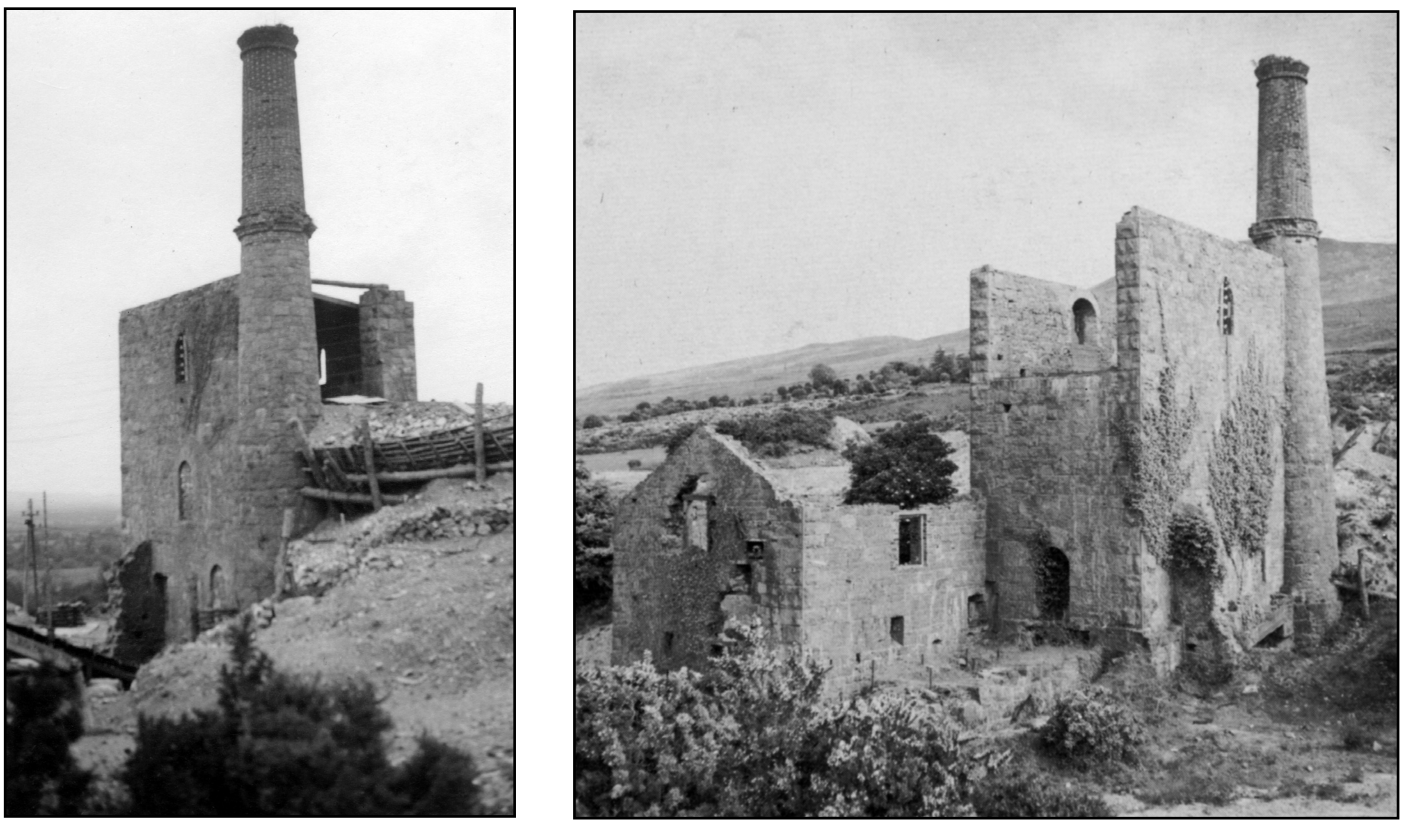
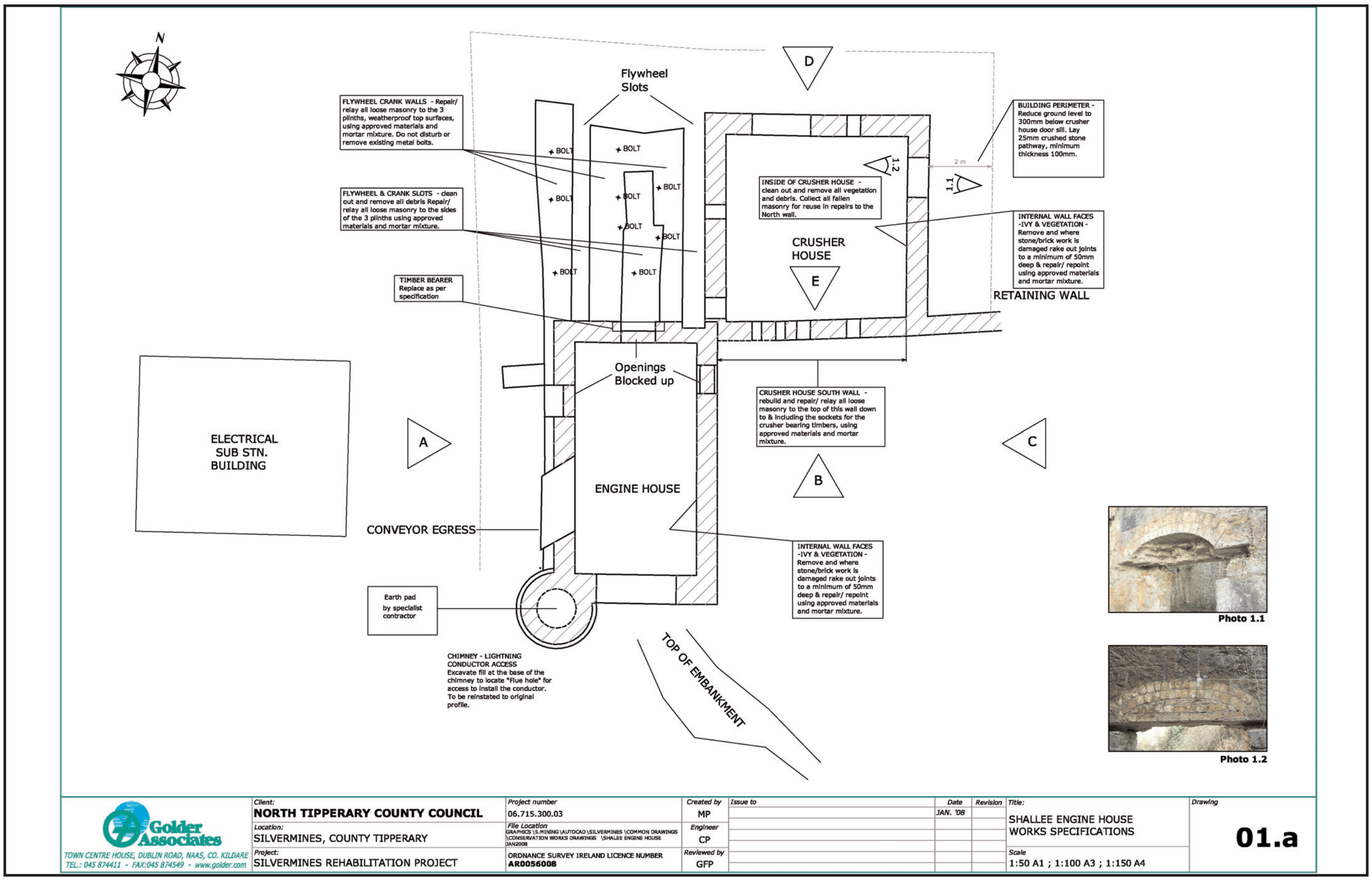


Figure 3. Two historic views of the derelict ruins of the Shallee Engine and Crusher (attached and to the left of the engine house) Houses as they appeared in 1953 (left) and c. 1960s (right). On the engine house note various adaptations reflecting the reconstruction of the building to serve as an ore bin during the 1948 - 1953 phase of operations: the lower height of the left hand (north) wing wall, supporting an inclined roof (left); electrical power insulator cluster in the window opening at the top of the right hand wing wall and, at its base, the top of the conveyor belt slot built into the original wall (right: conveyor system in situ in 1953). Traces of the lean-to boiler house on the left hand side of the engine house are visible in the left hand view in the form of a remnant section of lean-to wall and traces of flashing just discernible on the masonry and diagonally across the base of the chimney. Note also the deep slot in the rear wall of the building to the right of the chimney and at the top of the rubble filled ramp (absent in Figure 2): this rear slot is of very similar dimensions and design to the bob wall slot at the front of the building (compare left and right hand views). Left hand image reproduced from Hodnett (2007), original copyright Royal Institution of Cornwall; right hand image reproduced from Bird (1974).



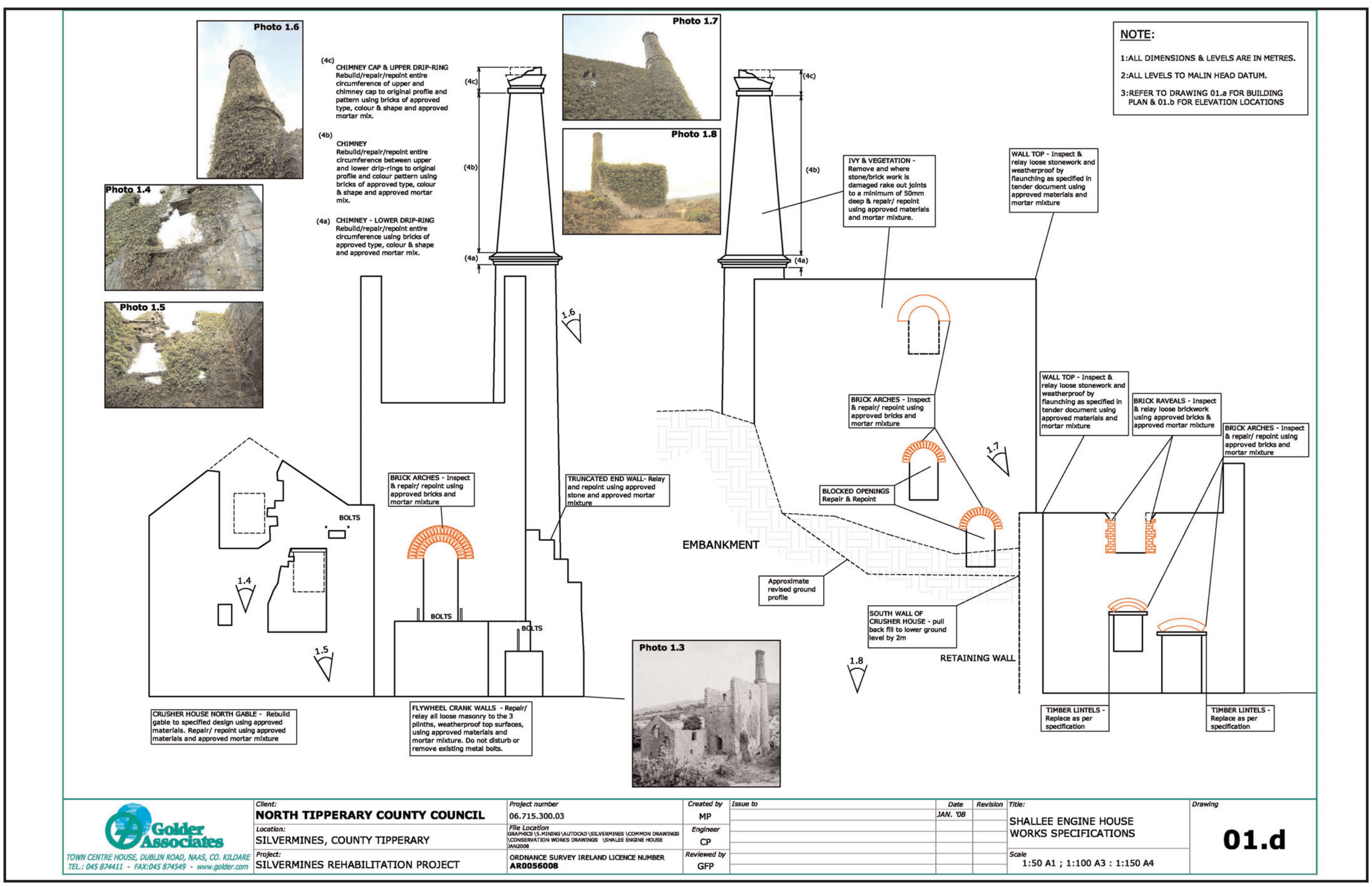


Figure 4. Scale plan of the Shallee engine and crusher houses (top); and front (north) and east wall perspectives of the Shallee engine and crusher houses (below). Note conservation works annotations and images in these and similar plans reproduced below. All such plans and diagrams formed part of the conservation works specification dossier prepared by Golder Associates (Golder Associates 2008).

Figure 5. General views of the Shallee engine and crusher house complex, looking northeast, before, during and after completion of conservation works.

Figure 6. Interior views of the engine house before and after clearance of trees and other vegetation (left and centre, both photographs Martin Critchley) and during conservation works (right).

This deep slot is clearly visible in the 1953 view of the Engine House reproduced by Hodnett (2007: Figs. 3, 11) although, sadly, there is no 1937 picture of the rear wall which can confirm or refute this interpretation.

If this interpretation is correct, which seems reasonable, then this is one of only two presently known examples of "double-bob" installations in surviving Engine Houses in Ireland, the only other noted at the Williams' Engine House, Avoca, Co. Wicklow (Brown 2002). However, in that instance, the rear bob appears to have served merely to operate the condenser due to lack of room for the normal placement to the front. Consequently the Shallee Engine House may be regarded as unique in Ireland as it serviced substantial operational functions to the front and rear. Whether or not the engine had sufficient power to operate all three functions (pumping, crushing, stamps) concurrently is unknown, although unlikely, in which case some type of gear control system would have been required to operate one, or maybe two functions at a time. Morris and Brown (2001) describe such a control system for the Man Engine House, Allihies, Co. Cork.

Sadly, the original interior of the building, from which evidence for this type of control system may have been evident, along with the size of the engine, was largely destroyed during the installation of a concrete bunker and an inferred electrically powered crusher system at some stage during the late 1940s/early 1950s. Part of this installation is evident in Figures 3 and 4 which shows the hopper input ramp constructed up to the "back bob" slot in the rear wall; and an inclined conveyor belt system to carry primary crushed ore out of the building through a low level opening made in the west wing wall. The latter opening and much of the ramp to the rear survive, as well as the internal concrete bunker and electricity insulators on a bracket within the window near the top of the west wing wall.

The Stevens report (1996) projected that the cost of consolidation works on this building in 1996 would amount to about IR£10,000, in contrast to an actual combined cost, for the engine house and crusher house, of Euro 115, 815 (incl. VAT at 13.5%) twelve years later in 2008. A substantial part of the latter amount reflected the cost of erection of scaffolding not only on both buildings but also the entire height of the chimney in order to effect repair works on the upper, brickwork section. The scaffolding cost about Euro 33,000 (incl. VAT).

Figure 7. Double flywheel slots, before, during and after completion of works. Note the axle bearing hold down bolts in all views.

Figure 8. General views of the chimney stack. The upper brickwork section is quite ornate, marked by alternating deep red brown bricks laid circumferentially and pale buff bricks laid radially as "headers" to create a very distinct pattern (see also Figure 9). Sections of the chimney were severely damaged by ivy and other growth, especially the drip ring and outward flared chimney cap.

6. SHALLEE CRUSHER HOUSE [Figs 12-16]

There is, at present, no technical or historical information published which describes either the history or design and operational features of the Shallee Crusher House. However, it may be surmised that it was probably built about the same time as the Shallee Engine House, in the late 1860s, and its overall dimensions, design and location of openings in the various walls bears a reasonable resemblance to the water wheel powered "old" crusher house at the Barravore Mine, Glenmalure, Co. Wicklow. Chester and Burns (2001) describe and illustrate in detail the design and operational configuration of the latter building. It housed a spring loaded roller crusher mounted at first floor level on robust wooden beams which spanned the building from front to back. Levers attached to the rollers projected through the front wall where they were attached to external counterweights which acted to maintain tension between the rollers, but allowed them to spring apart if a large block of ore jammed between them. The rollers were presumably fed by an overhead hopper system, for which no evidence now remains (though it does at the nearby "new" crusher house: Chester and Burns 2001), while crushed ore was presumably drawn out through a hopper below the roller at ground floor level and then out of the building for concentration in buddles etc.

External views of the Shallee Crusher House as it appeared in 1937 (Hodnett 2007: Figure 2. See Figure 3 also) provide little information about the internal operational configuration, though external openings at first floor level in the front wall may have accommodated roller counter weights as at Barravore. The position of the drive shaft from the flywheel (Figure 11) aligns with the presumed first floor level mounting position of at least one or maybe more sets of roller crushers, an interpretation supported by surviving openings in 2008 and even remains of very substantial beams in some internal openings (Figure 16). The remains of a high level (second floor) ore supply chute system is equally well preserved in the rear wall (Figure 16).

One of the two 1937 vintage photographs reproduced by Hodnett (2007: Figure 2, left) shows an almost square, roofless building above, and to the left of the crusher house, which resembles the crusher house in both style and scale. Sadly, nothing now remains of this building, although if it was a crusher house, then it may been associated with the 50 foot diameter waterwheel replaced by the Shallee Engine House in the late

Figure 9. Chimney cap, before start of conservation works (top row) and during conservation works (bottom row) before completion of re-pointing and installation of lightning conductor. Note the very loose and fragile state of the brick work, with saplings rooted into the structure displacing and loosening course work. The original ornate red-brown and pale buff brickwork style is well displayed in the centre picture of the lower row.

Figure 10. Chimney stack drip ring. Note course work very badly damaged by ivy; reconstruction in progress (centre) and after completion (right). Note the "put-lock" hole in the brickwork below the ring, marking the location of timber scaffolding used during the original construction works in the 19th C, and the very distinct diagonal groove which marks the abutment of the original engine house roof against the chimney.

Figure 12. General view of Shallee crusher house before, during and after completion of conservation works. Note the partially collapsed state of the ivy covered gable wall (left: and Figs. 13 and 14 below) and compare with its still intact state in the 1960s (Figure 3). The very precarious state of this wall presented the most serious conservation works challenge of the entire project. See plan and elevation views, Figure 4.

Figure 13. Interior views of the gable (north) wall: prior to commencement of works when the upper left hand section of the wall was on the verge of collapse (Left, photograph Martin Critchley. See also Figure 14 below); during reconstruction from the ground up, this view of two brick pillars with reinstated wooden lintel concealing load bearing galvanised RSJ girders within the wall (centre); and the fully reconstructed wall (right: pillars shown in centre image located in lower left part of wall at base of reconstructed section of masonry).

Figure 14. Gable wall, illustrating both the very precarious state of the wall prior to conservation works (left photograph Golder Associates) and centre left and the location and reconstruction of masonry and lintels around an in situ axle bearing in the upper left section of wall. Centre left and centre close up of axle bearing prior to works, and centre right and right, exterior and interior views after reconstruction of masonry and lintels around the cast iron bearing frame.

FACING PAGE (bottom row): Figure 11. Remnant of electricity insulator assembly, upper west wing wall (left); a view of the rear of the engine house after completion of conservation works showing complete re-pointing of the chimney stack brick work and the deep slot of the rearward projecting back bob (centre); and part of presumed drive shaft assembly in the crusher house/flywheel slot wall (right).

1860s (Brown 2003). It may be surmised that the water powered system would have been kept in operation during the construction of the replacement steam powered installation, and either the crushing machinery transferred from the old crusher house to the new one once the engine was operational, or the water supply system modified to provide water to the engine house boiler, or the two systems were maintained in operation concurrently.

Figure 15. Reconstruction of the upper part of the gable wall: pitch of reconstructed section projected, by light cord, from surviving sections of masonry, to a projected apex marked by a light timber frame visible in the centre view.

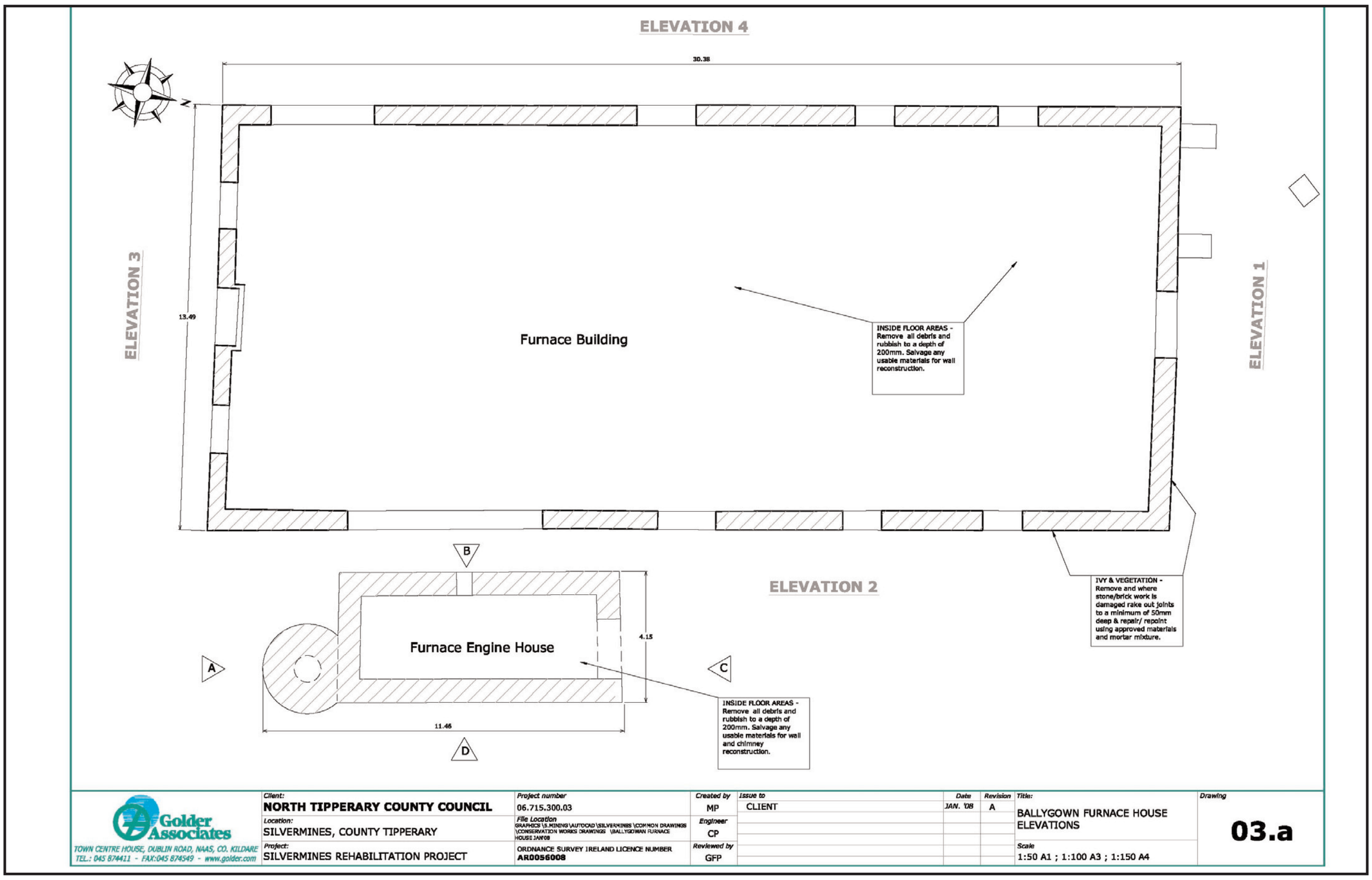
Figure 16. Rear wall of crusher house. Note surviving in situ sections of substantial timber beams prior to commencement of works (left: both had to be removed - part of one is visible in the foreground of the centre left image - as both were severely affected by invasive timber rot). Note the very substantial beam openings below the level of what are presumed to be joist slots for a second floor level - see also matching slots in the front wall, Figure 13 - and the presumed ore feed chute extending from above the joist level to just above the level of the main timber beams. The centre right image shows the brick reconstruction of the chute walls.

7. BALLYGOWAN CRUSHING ENGINE HOUSE [Figures 17-22]

In May 1854, Captain Hambly of the GMCI purchased a 24 inch steam engine "and adjuncts" for £780 in Cornwall. This was shipped to Silvermines and there erected in Gurtnadyne to power a crusher installation which was operational by December 1854 (Brown 2003). The associated crusher installation may reasonably be interpreted to be that purchased by the GMCI from Harvey's of Hayle, Cornwall in August 1854 for £160 and shipped to Limerick on the "Carnsew" (presumably the name of a ship: Cundick 2002). Brown (ibid) suggests that this engine, and presumably its associated crushing machinery, was moved to and installed in the small Ballygowan Crusher Engine House in 1861. It may be surmised that this operational function continued up to 1866, when the adjoining Calamine building was constructed and the engine adapted to power installations therein (see below).

The small, 4 foot stroke rotary engine was enclosed entirely within its Engine House, in appearance identical to the still surviving winding engine house installation at the Levant Mine, Cornwall (Brown 2003). There were originally four such engines at Levant which were gradually sold off and one advertised for sale in December 1852 might perhaps be the engine purchased by Captain Hambly in May 1854. Apart from surviving remnants of the support structure for the high level trunnion cross beam or entablature, nothing now survives of the engine loading, the front wall of the building or its boiler house which was located on its eastern side. Now closed up openings in the west wall of the engine house, between it and the very closely adjoining east wall of the "Calamine" building (see below), probably serviced drive shafts to a longitudinal or "table engine" to power surface machinery, including "calominers"(a form of reverbatory furnace) in that building (Brown 2003).

Part of the masonry base of the boiler house chimney is built into the south-east corner of the engine house. The chimney had survived relatively intact until it was blown up for safety reasons in the 1980s (Brown 2003 and De Staffort, pers. comm.; Figure 21).



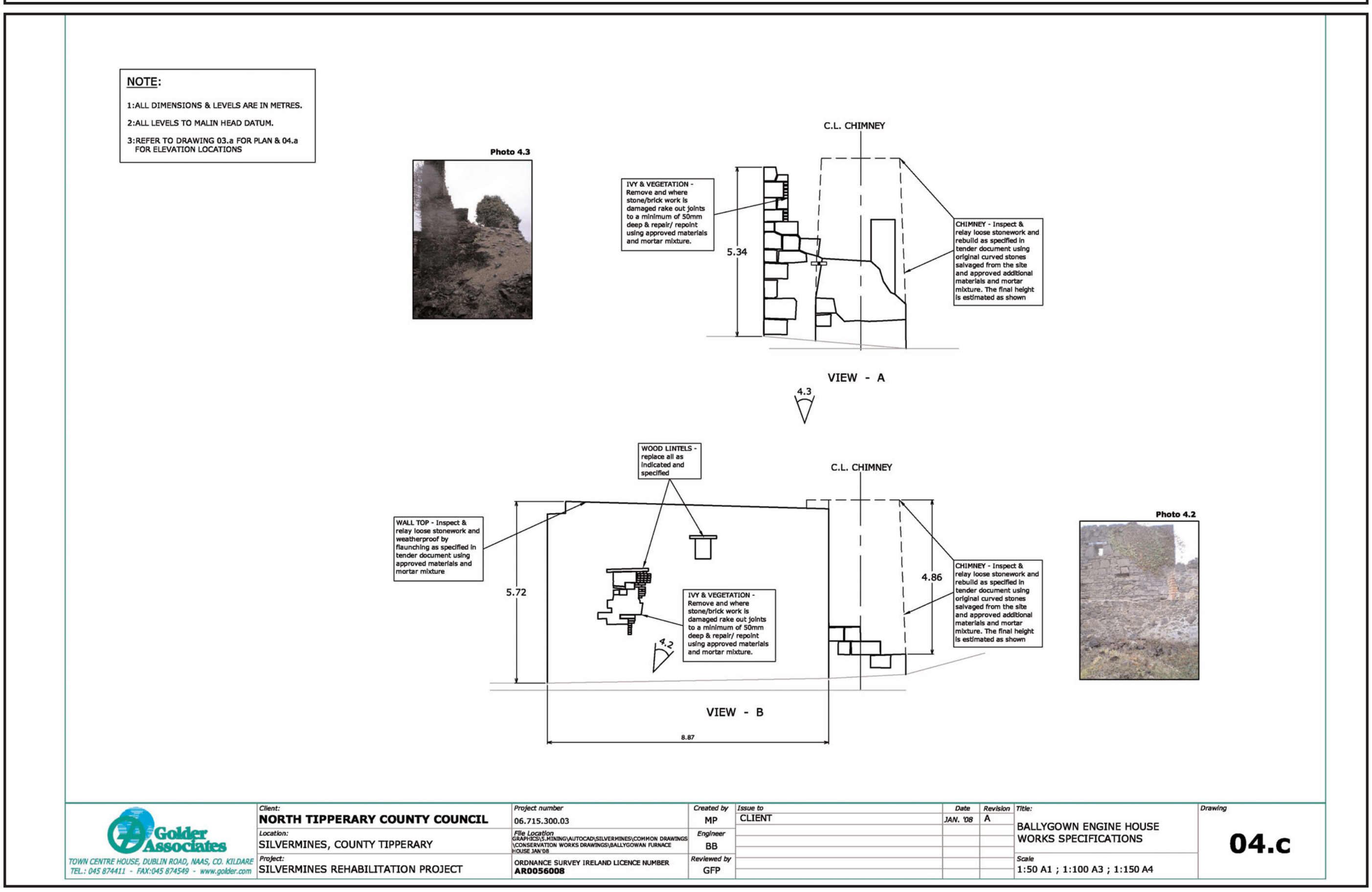


Figure 17. Scale plan of the Ballygowan calamine ("furnace") processing building and associated crushing engine house (left); and annotated elevation views of the north (front) and west wing wall of the engine house (right: Golder Associates 2008).



Figure 18. Views of the crushing engine house before (left, two tall ivy covered masonry walls); during and after completion of conservation works (last view prior to erection of a safety fence). Note the heavily overgrown area between the two wing walls in the pre-conservation view which corresponded with a backfilled pit visible in the middle and right and views (see also Figure 22 below).


Figure 19. Pre and post conservation works views of the narrow gap between the engine house and the calamine building.



Figure 20. Views of the west wing wall of the engine house viewed from inside the calamine building before during and after completion of conservation works. Note the reconstructed and repointed masonry sections in the wing wall (and also in the calamine building wall in the foreground). The timber lintel visible in the pre and post works views was not replaced as it was in reasonable condition.

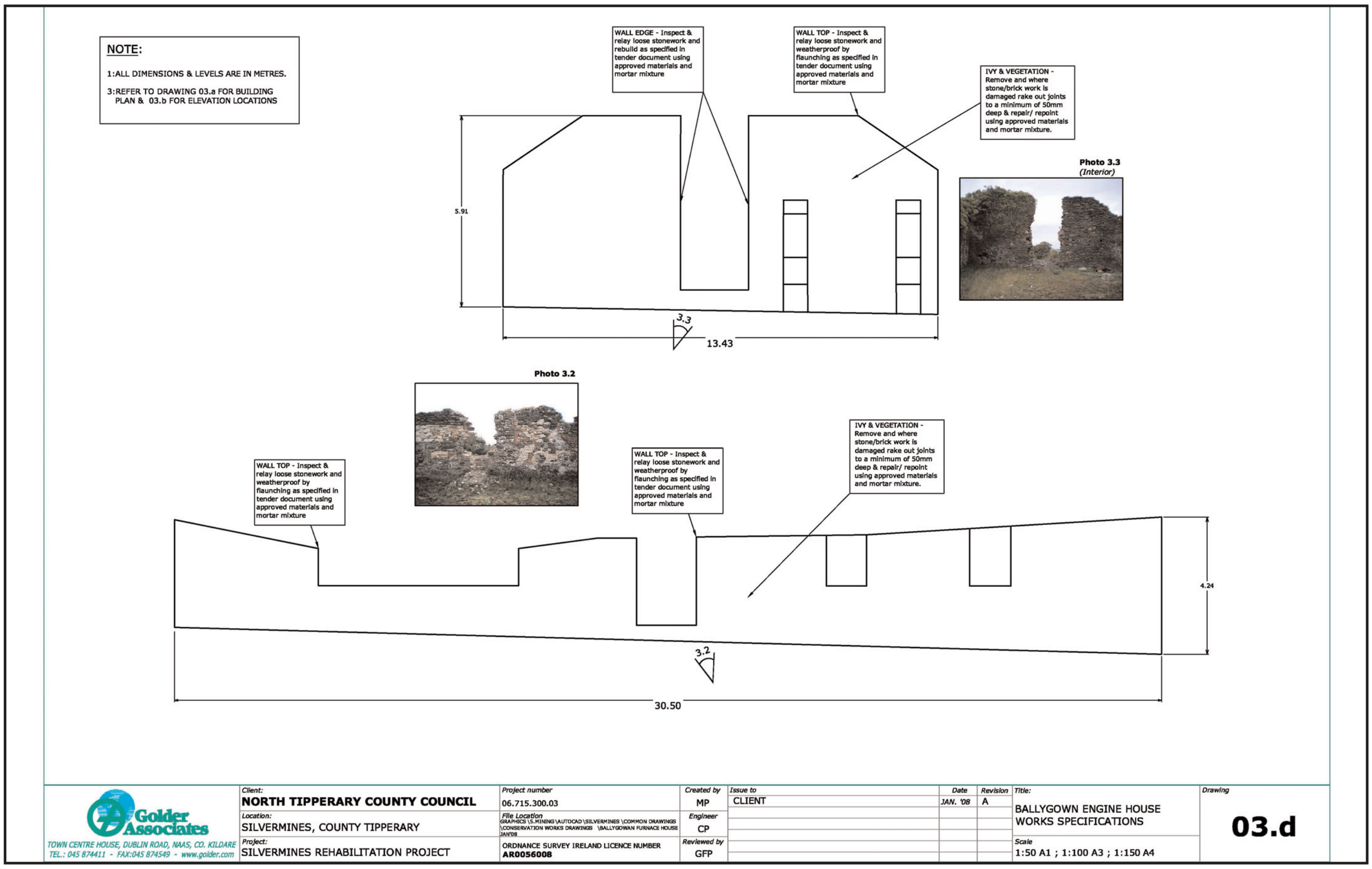
Figure 21. Engine house chimney stack: top row views of it prior to demolition in the early 1980s (top left, photograph courtesy of Eamonn de Staffort; note drip ring and remnant of upper brickwork section); as it appeared prior to commencement of site clearance in 2008 (top right) and immediately prior to commencement of reconstruction (bottom left with Gino Baral of "Scopriminiera", Italy); during reconstruction; and after completion of all works (bottom right).

Figure 22. A close up view of the backfilled section between the wing walls (left) which, during site clearance, revealed the remnants of the cataract pit and crow hole (middle). Remnants of the cylinder bed stone were found in an adjoining pile of rubble and placed back into the building after completion of works (right).

8. CALAMINE BUILDING [Figures 23-29]

Cowman (1988) indicates that this building was probably constructed in 1866 and operated to roast calamine ore to produce zinc oxide between 1866 and 1872 and possibly into early 1873, although Boland *et al*. (1992) note mining operations between 1862 and 1874. Cowman (1988) notes that the GMCI decided very ambitiously to construct this building to house a bank of eleven furnaces, when perhaps one might have been sufficient - and more financially prudent as there proved to be little market demand for the end product. Brown (2003) describes closed up openings between this building and the very closely adjoining crushing engine house, as already noted in the description of that building above. Boland *et al*. (1992) note that the zinc oxide end product was collected in a bag house. Sadly, nothing further is known about the design or operation of this building which remained relatively intact, with a roof, until at least the 1960s (Eamonn de Staffort, pers. comm.).

Boland *et al*. (1992) provide a detailed account of the geology and mineralogy of the residual zinc-lead deposits of the Silvermines area, including the "calamine", all of which are interpreted to have been formed by deep, near surface weather-



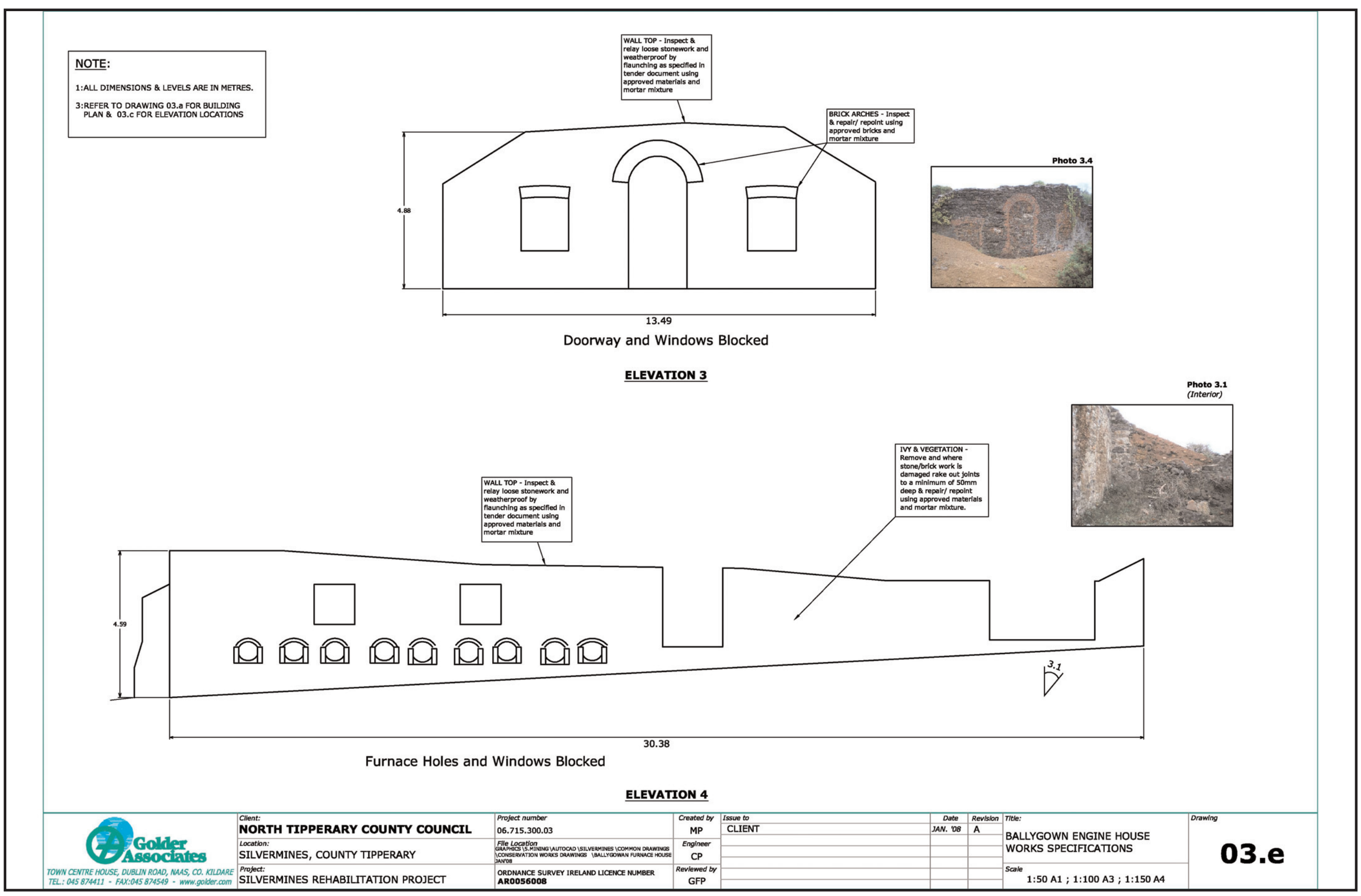


Figure 23. Annotated elevation views of the Ballygowan calamine building (see plan view Figure 17): external view of the front (north) entrance wall and west wall (left); and external views of rear (south) and west wall in which the location of 9 of the recorded 11 calomine furnaces is clearly visible (right: Golder Associates 2008).

Figure 24. Four views of the calamine building prior to commencement of conservation works: top left - view looking south-east, showing the front entrance to the building on the left; and from the rear, looking north along its length (top right, photograph Martin Critchley). Note the bank of very distinctive ochre coloured spoil in the foreground; the ivy covered wing walls of the engine house immediately adjacent to the north wall of the building; and a large, infilled brick arched doorway in the rear wall of the building (see Figure 23 also). The lower left hand view (external wall section near front, north side of building: Chris Price of Golder Associates in foreground) shows 9 brick construction arches in the lower part of the wall which may represent the location of draw points for 9 of the 11 recorded "calominers" in the building (see Figure 23 also): note part of the very distinctive "ochre" spoil heap on the right hand edge of the view. The lower right hand presents a more detailed internal view of four of the brick arches, with an infilled, larger diameter circular opening above within a very complex masonry and brick wall construction. It is presumed that the ochre spoil waste present in the adjoining spoil heaps was extracted from either the lower draw points or possibly from the larger openings above.

ing of primary sulphide ore minerals most probably under the hot, humid conditions which prevailed during the late Tertiary period (c. 3.6M to 1.6M years ago). They note that the "calamine" ore, primarily a mixture of the zinc carbonate mineral smithsonite, $ZnCO_3$ and hemimorphite $Zn_4SiO_7(OH)2.H_20$ (with or without the lead carbonate mineral cerussite, $PbCO_3$) was mined intermittently from the 17th Century onward from the Ballygowan South area and Knockanroe, both due south of the village of Silvermines and south and west of the Calamine Building respectively. They note that between 1862 and 1866, when the calamine building was constructed, the calamine ore was "washed" to remove "ochre", a complex of red to reddish brown coloured iron oxides and hydroxides which give the surviving spoil heaps near the calamine building their very distinctive colour (Figs. 24, 27). The washed ore was then shipped to Britain for smelting, presumably during the period between 1860 and 1865 before the decision in 1866 to construct the building (see discussion, section 1 above) . Griffith (1955) notes that the roasting process could only profitably treat high grade ore, while relatively "low" grade ores containing between 12 to 17% zinc was discarded. Exploration work undertaken by Ennex International between 1984 - 1990 indicated a total residual ore resource of 1Mt of ore grading 10.79% zinc + lead: this resource figure includes calamine ore remaining in the vicinity of Silvermines as well as other types of residual ores at this and other locations (Boland *et al*. 1992).

Figure 25. Views of the front entrance of the calamine building before, during and after completion of works.

Figure 26. Views looking along the length of the calamine building, from the front entrance area, before, during and after completion of works. In the right hand image note the top of the engine house, on the left, and ochre spoil heap on the right.

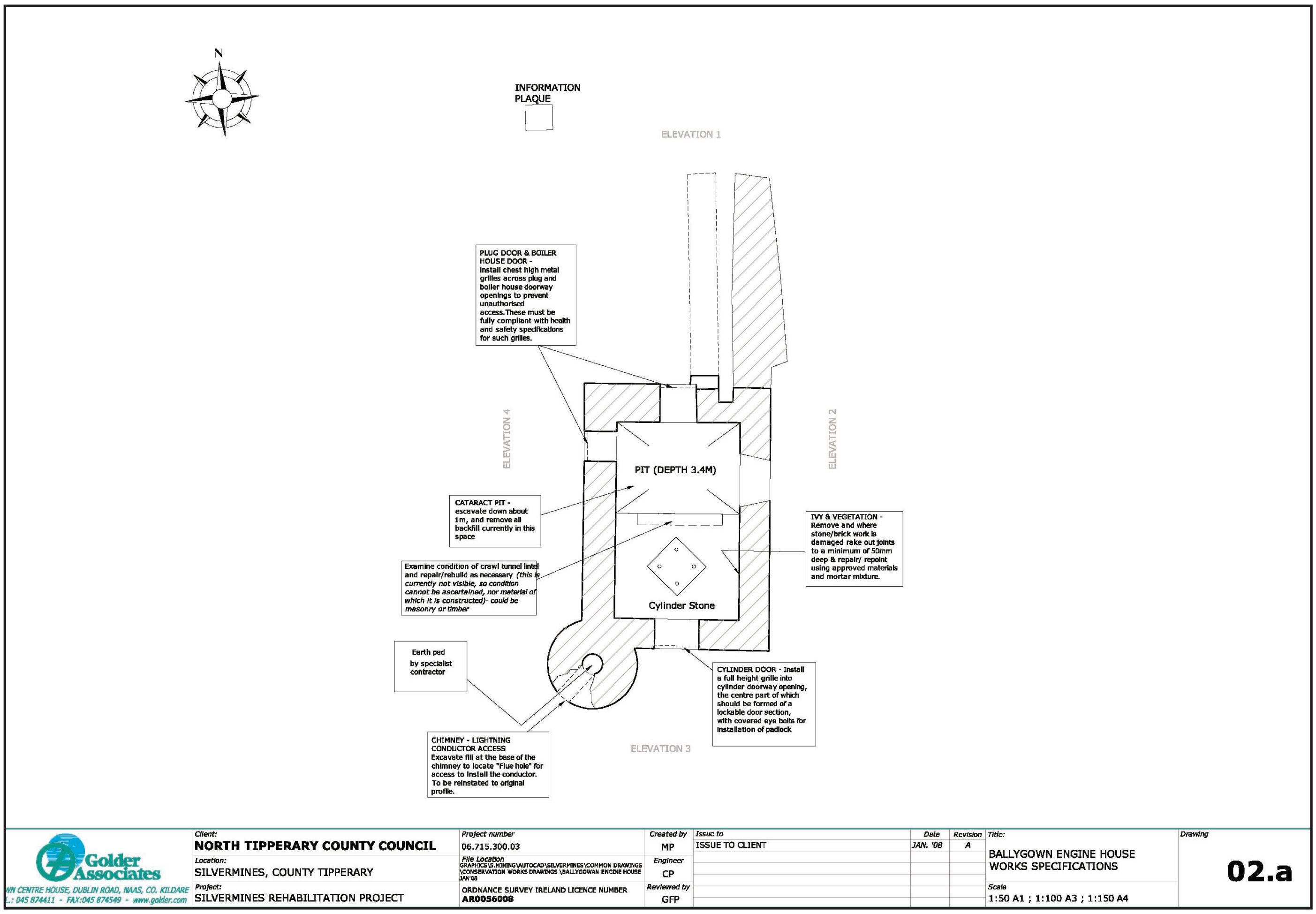
Figure 27. Various views of conservation works in progress: front, rear and wing walls (left); top of front left hand (north) wall (middle); and south wing wall, with ochre spoil heap to rear (right).

Figure 28. Interior views of front entrance wall before and after works.

Figure 29. Internal and external views of front section of west wing wall during conservation works, to show location of presumed "calominer" draw points towards the front end of the building. It is postulated that the rear part of the building, adjacent to the engine house may have served as an ore crushing zone, powered by the crusher engine, with ore drawn through the now infilled doorway in the rear wall (Figure 23).

9. BALLYGOWAN (SOUTH) ROTATIVE PUMPING ENGINE HOUSE [Figures 30-37]

Brown (2003) provides a quite detailed description of this building, albeit under the incorrect name "Ballygahan". He notes that it was probably built after 1861, and that it housed a c. 28 inch diameter, single acting engine. This was connected externally to a flywheel 30 feet in diameter through a highly asymmetric stroke ratio of 7 feet indoors and 10 feet outdoors. The flywheel crankshaft loading indicates that it operated as a single function installation only driving a set of flat rods connected via an angle bob to pump rods extending down the mine shaft located about 120 feet to the north, in front of the engine house. This "engine shaft" is reputed to have extended to a depth of about 50 fathoms (300 feet, c.91m) with its principal working levels at 15 and 30 fathoms, albeit these forming part of a maze of internal winzes and winding levels likened to " a large rabbit burrow" (Griffith 1955). The lean-to boiler house was located along the west side of the building abutting the chimney stack which is built into the south west corner of the engine house. The building remained in use up to about 1872/3 (Cowman 1988).



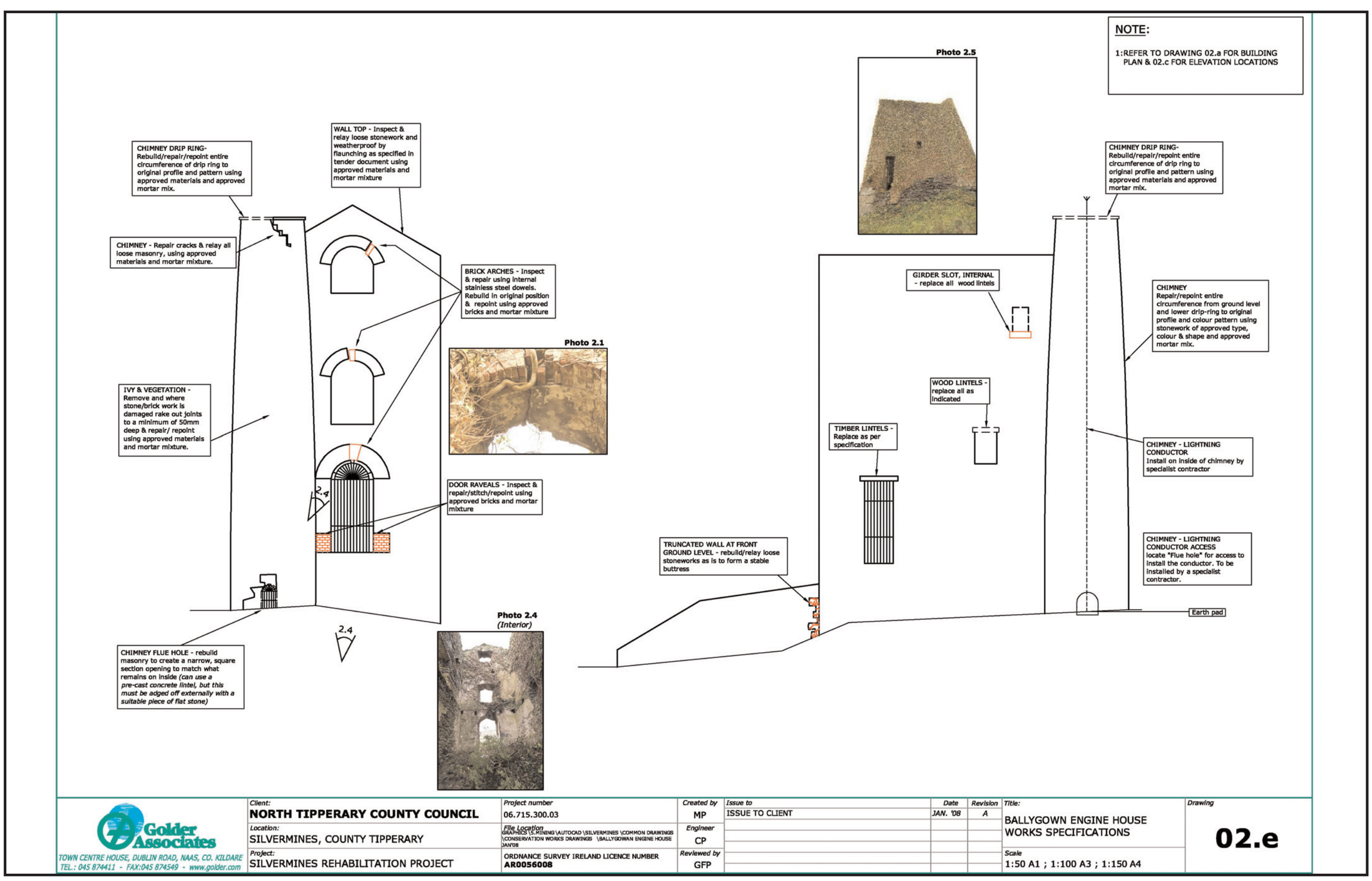


Figure 30. Annotated plan and external elevation views (rear, south wall, and west wing wall) of the Ballygowan pumping engine house (Golder Associates 2008).

Figure 31. Bob wall (north) elevation : before, during and after completion of conservation works. Note reconstruction of fly-wheel slot and mounting plinth on left; reinstatement of plug doorway lintel (see detail below, Figure 37) and trunnion bearing timber; and extensive re-pointing. The boiler house was located on the right hand side of the engine house.

Figure 32. Gable (rear, cylinder doorway) elevation, before during and after completion of conservation works. This elevation was very severely damaged by pervasive ivy growth, in particular the arches above the door/window openings (see details below, Figs. 34, 35) and virtually the entire elevation had to be re-pointed (left image, Martin Critchley).

Figure 33. Exterior and interior views of the east wing wall before, during and after conservation. Note partially collapsed interior wooden lintels before replacement (interior view). The adjoining masonry here and elsewhere required the installation of temporary steel bracing bands of the type shown in Figure 37 to support the masonry during replacement of lintels, and arches in some instances.

Figure 34. Exterior (left) and interior views of the gable elevation before commencement of conservation works. Ivy growing through and rooted into masonry and brickwork had very severely damaged sections of this wall, especially the lowest arch (right) and all arches had to be extensively reconstructed. This included insertion of stainless steel stabilising pins within wall sections.

Figure 35. Close up internal and external views of the middle window arch before, during and after completion of conservation works. Note structural cracks and partially collapsed keystone brickwork section (left); use of a timber arch form to support reconstruction of the brickwork arch (centre); and the arch after completion of works. The structural cracks were stabilised by use of stainless steel pins inserted within the wall sections.

Figure 36. Chimney stack before, during and after conservation works. Note pervasive vegetation growth over and rooted into masonry, and partially missing drip ring masonry (bottom right); fully rebuilt and repointed drip ring and masonry (top left and right); damaged flue opening at chimney base (bottom left) and after reconstruction and repointing (bottom middle).

Figure 37. Plug doorway before and during archway reconstruction and lintel replacement (left and middle); and view of temporary steel stitching braces to support masonry above window in west wing wall before removal and replacement of timber lintel (right: compare with Figure 31 right image).

10. THE SILVERMINES WÄLZ/WAELZ PLANT COMPLEX [Figures 38-43]

While this paper has focussed primarily on the conservation of the extant remains of 19th Century mine heritage buildings, efforts were made throughout the period 2007 to 2009 to achieve conservation of the mid-20th Century Wälz/Waelz Plant complex, scheduled for demolition on health and safety grounds as part of the environmental remediation works programme. This is an unique complex in Ireland, and notwithstanding that it is of relatively recent vintage, it represents an attempt to apply more modern technology to the extraction of zinc from the calamine ore. It is thus a continuation of the mid-19th century enterprise and part of a constantly evolving processing technology and mine heritage, and notwithstanding its relative modernity, it could and should form part of the heritage resource for future generations.

While efforts to achieve its conservation seemed doomed in 2008, and all buildings destined to be reduced to c. 1m high wall stumps, the renewed efforts of the "Silvermines Enhancement Group" (SEG) since then has managed a "stay of execution" and the buildings still stand intact at the time of writing (September 2011). In 2010 the SEG developed a plan to conserve and adapt for other purposes the very tall and slender zinc "bagging" plant (see below), arguably the most iconic of this particular set of buildings (E. de Stafford, pers. comm., 2011). The group also commissioned a report by consultants Donaldson Tourism and Heritage to develop an appropriate tourism product for the site.

To support these very recent conservation efforts, this section presents a brief review of the Waelz Kiln process and a summary of the history of this complex as a preamble to a presentation of an image archive of the complex as it appeared in 2008. The summary history, and technical information, is taken entirely from the very lengthy and very detailed account provided by Griffith (1955) of operations between 1948 and 1952/3, unless otherwise cited.

The principle of the Waelz kiln technology was first proposed in Germany in 1881, where it was patented in 1913 and the first plant erected there, at Lünen, in 1925 to recover zinc from low grade zinc ores (Anonymous 2009).   The Waelz process centres upon subjecting zinc ore, admixed with a carbonaceous flux in a rotary kiln, (Figs. 38, 40) to a sufficiently high temperature to cause metal species to volatilise into flue gases from which the metals are recovered as oxide concentrates. The web site of the "National Metal Resource Finishing Centre" (http://www.nmfrc.org/bluebook/sec73.htm) provides the following generic description of the process:

> "At the heart of the Waelz kiln technology process is a rotary kiln which is typically up to 180 ft (50m) in length and up to 12 ft (4m) in internal diameter. Kiln feed consists of blended metal-bearing sludges and oxidic dusts mixed with an appropriate amount of a suitable reducing agent (coal, petroleum coke or metallurgical coke fines). During passage through the kiln, the mixed charge is heated under the resulting reducing conditions to a temperature of 1,300°C, sufficient to volatilize the reduced metal species from the charge. The volatilized metal values are subsequently re-oxidized in the gas stream above the charge, and this product is finally collected in bag houses as an enriched fume product. Two products are generated from the Waelz process: crude zinc oxide ("Waelz oxide", Fig. 38) and iron rich material ("slag", Fig. 38)."

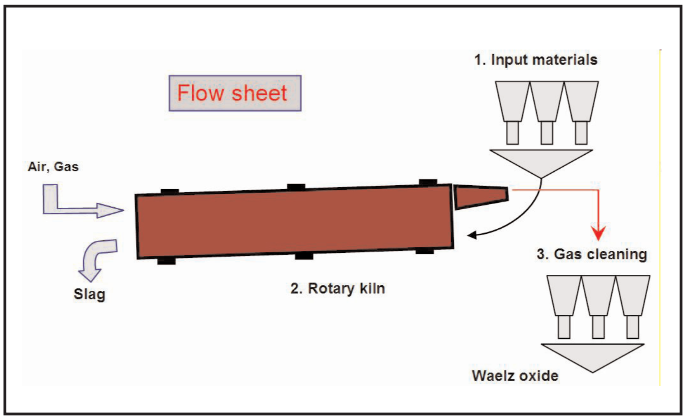


Figure 38. A schematic diagram of the Waelz process (from http://www.vtt.fi/liitetiedostot/cluster5_metsa_kemia_ymparisto/CS_Waelz.pdf)

Figure 39. (above) The Silvermines Waelz plant under construction in 1950. Note the tall, slender "bag house" in the background. Foundations for the Waelz kiln and burner house under construction between tripod scaffolding and the bag house. Image courtesy of E. de Stafford. (right) An image of the completed plant system showing the kiln in the foreground; the burner unit used to pre-heat the kiln to c. 1000°C; the gas flue, to the right of the kiln, which conveyed volatilised metals from the kiln to the bag house; and the bag house in the background. Image from Griffith (1955, his Figure 11).

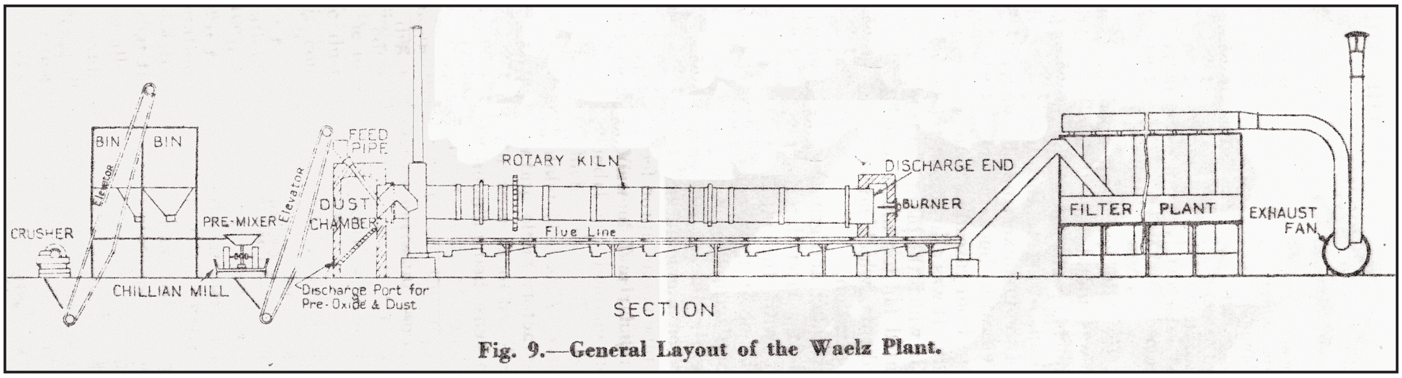


Figure 40. A schematic diagram of the Silvermines Waelz plant system provided by Griffith (1955: his Figure 9).

The application of this technology to the recovery of zinc oxide concentrate from calamine ore at Silvermines was first considered in 1934 by the British (Non-Ferrous) Mining Corporation (see section 2 above also) but it was not until 1950 that a Waelz plant was constructed at Silvermines by the Silvermines Lead and Zinc Company Ltd (see also Section 2 above: Figure 39).

Griffith (1955) provides a very detailed account of the construction and operation of the Silvermines Waelz plant, including various operational problems, only a précis of which is presented here. The plant was constructed at a total cost of IR£23,288, a sum which includes the itemised costs for various parts of the complex, for example the "bag house" building (Figure 39) which cost IR£2,388 to construct, while the furnace building cost IR£2,693 (low building between the kiln and bag house, Figure 39, right). Griffith (1955: his Figure 9, reproduced here as Figure 40) provides a schematic diagram of the Waelz installation which is used here to illustrate and describe briefly the operation of the process at Silvermines.

The Silvermines complex consisted essentially of three principle sections: a crushing, mixing and grinding section (the "feed" plant systems to the left of the kiln in Figure 40, equivalent to the "input materials" section in Figure 38); the Waelz Kiln (Figure 40, centre); and, to the right of the kiln, a "bag house" to recover zinc oxide (Filter plant, Figure 40).

The "feed" system consisted of a bank of three storage bins, one for anthracite "duff" (sourced initially from the Slieve Ardagh coalfield), one for sand and one for crushed ore supplied by a 6 ton/hour ore crusher. Required proportions and weights of the feed material were drawn from these bins by wheelbarrow initially into a pre-mixer for thorough mixing, after which the mix was discharged into a "Chillian" mill for further milling down to an uniform size of ½" (c. 1.25cm) before discharge into a 9" (c.22.8cm) diameter feed pipe into the Waelz Kiln, along with any dust recycled from "baghouse" flue gas.

The kiln was designed to process up to 5 charges/hour of feed material admixed in an average proportion of 5 cwt of calamine, 2.25/2.5 cwt of anthracite, 0.75 cwt flue dust and sand as required. The steel shell of the refractory brick lined kiln was 0.5" thick (1.25cm), 87' long (26.5m) with an internal diameter of 5' 11" (c. 1.8m). It was set at an inclination of 2^o, rotated at about 1 r.p.m and heated up to an operational temperature of c. 1,000^{o}C by an oil fired external burner, which was stopped once the exothermic reaction of the kiln charge commenced. The volatilised zinc created a distinct green coloured flame in the main reaction zone of the kiln and this zinc oxide gas was drawn up the inclination of the kiln (in a direction opposite to that in which the reaction charge was inserted) by a draught created by an exhaust fan located in the "baghouse" through a line of flues which passed below and along the length of the kiln back toward the "baghouse" ("filter plant", Figure 40).

Zinc oxide dust was recovered in the bag house from the flue gas by passing it up through a series of vertically hung woollen bags which measured 128" (3.25m) in length and 8.6" (2.6m) in diameter. The bags were arranged in sets of 14 in each of 14 compartments, which in aggregate measured 35' (10.7m) in length, 15' (4.6m) wide and 5' (1.5m) deep. Each compartment could be operated independently and sequentially allowing gas to pass up through the wool filters and deposit zinc oxide onto the filter surface. Through a sequence of valve controls, flue gas could be switched from one compartment to another, thus allowing oxide to be recovered from the filters in a closed compartment by a combination of mechanical shaking and a downward air draught. The zinc oxide dust fell down into a hopper collection system where it was carried by a screw conveyor for bagging into 19" to 36" (48-91cm) long paper sacks, each containing from 80 to 112 pounds (36.3 - 51 Kgs) of oxide for export.

Figure 41. A view of the Silvermines Waelz complex buildings, as they were in May 2008 (view taken from scaffolding on the Ballygowan pumping engine house).

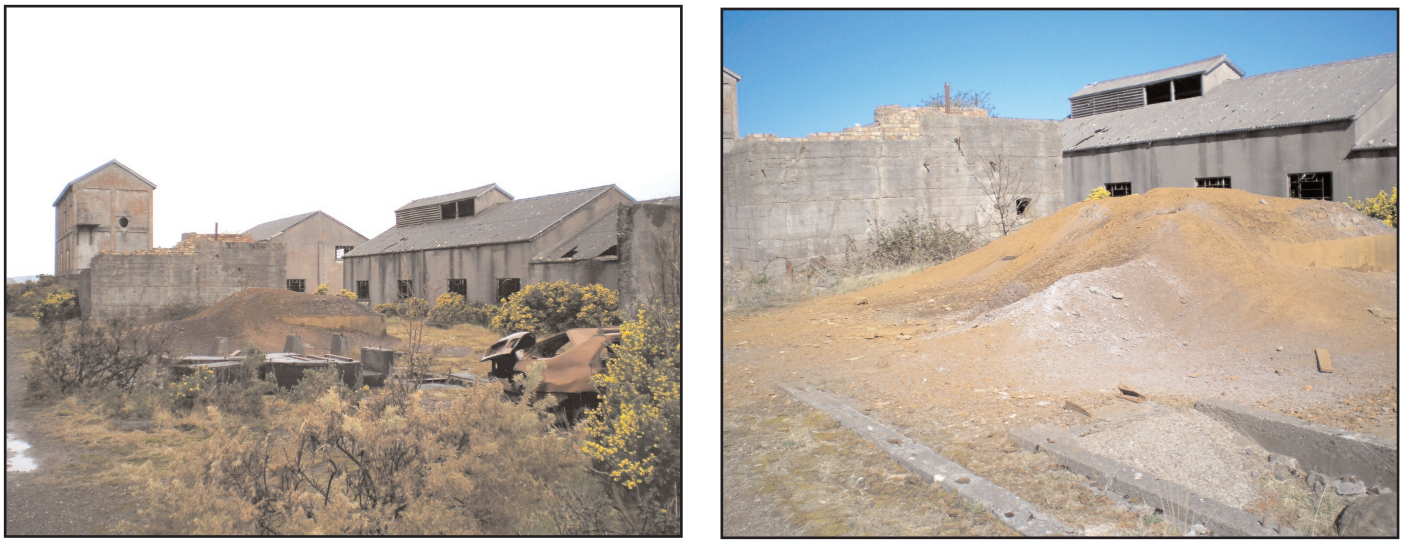


Figure 42. Walz kiln site as it was in 2008 (compare with view of this part of complex under construction in 1950 Figure 39): left and right images, waste slag marks presumed discharge point of the Walz kiln; remains of the burner house behind it; and the slender bag house in the background.

Figure 43. Views of the bag house, top left and bottom left, and other buildings on site.

Figure 44. The InterClean conservation works team at Shallee: Bill Cregan, the works supervisor, third from the left.

From the outset, the operation of this plant was bedevilled by a variety of operational problems, some of which required quite radical modifications to the original design, as well as changes in production objectives (intermittent production of higher grade and more valuable zinc "white" for use in paint and rubber manufacturing). Caking of the kiln charge to form "rings" on the surface of the brick lining was arguably the most significant operational problem and reduced functional efficiency quite significantly. While increasing the internal kiln temperature provided a temporary solution, the problem generally necessitated periodic shut down of the kiln to facilitate removal either by use of hydraulic drills, or by use of an "industrial gun" to shoot out segments of the rings, thereby weakening the remainder of the ring causing it to collapse. The brick lining could also suffer damage as a consequence of ring formation, necessitating repair by manual replacement of damaged sections. Another albeit more minor problem concerned the quality of the anthracite duff which became increasingly inferior over time leading ultimately to its substitution by more expensive coke "breeze".

Over the course of its operation between construction in 1950 and cessation of operations in October 1952, the Silvermines Waelz plant produced a total of 790 tons of concentrate grading 59.04% zinc and 7.54% lead (see section 3 above also).

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