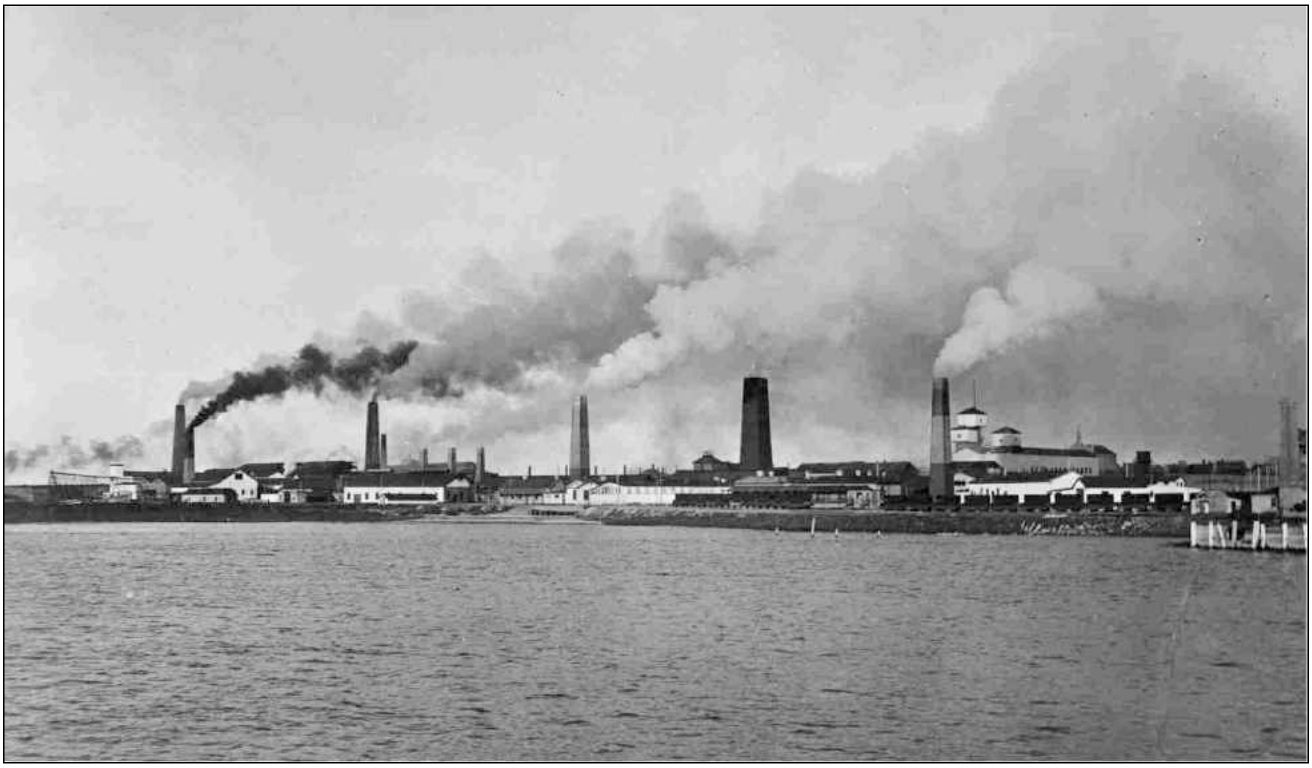
Wallaroo Smelters Site: Heritage Assessment

Report to Incitec Pivot Ltd



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Contents

Plans

Figures

Wallaroo Smelters: Recommendations

1 The Wallaroo Smelters Site should be re-defined with a clear boundary, distinguishing it from the remainder of the Incitec Pivot land, which contains nothing of significance.

2 This should be recognised by excising the Wallaroo Smelters Site from the remainder of the Incitec Pivot land as a new allotment on a new certificate of title. The proposed boundary of this allotment is shown on Plans 7 & 8, pages 58 and 59.

3 This new allotment should be entered in the South Australian Heritage Register and declared a place of archaeological significance.

4 A permanent fence with appropriate vehicle and pedestrian gates should be erected around the new allotment to define it physically.

5 The District Council of the Copper Coast, the Heritage Branch and the Coast Protection Board should be consulted about these proposals. (This will happen in any case as part of the development approval process.)

6 Ownership of the new heritage allotment should be transferred to the District Council of the Copper Coast.

7 The remainder of the Incitec Pivot land, including the fertiliser factory buildings, should be removed from the South Australian Heritage Register, with the exception of the former fertiliser company office on Charles Terrace.

8 The former fertiliser company office on Charles Terrace should be entered in the South Australian Heritage Register as a separate place. This should be done after it has been surveyed onto a new allotment as part of subdivision of the land.

9 Public access to the new heritage allotment should be encouraged.

10 To facilitate public access, minor site works and rubbish clearance need to be done for safety and aesthetic reasons.

11 A walking trail through the smelters site with interpretation signage should be established on the new heritage allotment.

12 The most appropriate public entry point to the walking trail is the former railway gates off Jetty Road at the south end of the site, close to the Wallaroo Heritage and Nautical Museum.

13 A quantity of granulated slag should be retained on the new heritage allotment.

Wallaroo Smelters Site: Heritage Assessment

Background to this Report

Historical Research Pty Ltd has been engaged by Incitec Pivot Ltd to undertake an assessment of heritage values at the site of the former Wallaroo Smelters, to be presented in the form of mapped data. The brief for the project is an appendix to this report.

The Wallaroo Smelters operated between 1861 and 1926 on a site on the foreshore at Port Wallaroo on Spencer Gulf. Their principal business was smelting the copper ores from the mines at Moonta and Kadina nearby, one of Australia's foremost nineteenth century copper mining districts, but there were also episodes of treating silver-lead and gold ores. After the smelters closed, the major structures were demolished, and the site sat abandoned and derelict for over eighty years. A superphosphate factory which had opened in 1900 continued to manufacture fertiliser on part of the site until the 1990s.

Hughes Stack, the largest and most monumental surviving element of the smelters, was entered in the National Trust Classified List in 1974. After the South Australian Heritage Register was created, the stack was interim listed in 1980 and entered in the Register in 1983, as an almost automatic result of its being recognised by the National Trust.

In the 1980s there were proposals to redevelop the foreshore adjacent to the smelters site. Unsure about the impact of these developments, the Department of Environment and Planning commissioned an archaeological survey of the smelters site (Bannear 1985) which made it clear that there were many historic structures other than the stack surviving within the site. Consequently the entire site was entered in the Register in 1986, with the new name Wallaroo Smelters Site. As a result of concerns expressed by Adelaide and Wallaroo Fertilisers, the site owners, there were specific understandings that although the fertiliser factory stood on the same land titles as the registered place, its operations would not be affected, and that granulated slag could continue to be extracted from the site for industrial purposes. (National Trust file 1834; Heritage Branch file 10137)

Heritage Drive was constructed along the foreshore of the smelter site in 1986. Since then there have been extensive marina and residential developments on the coast immediately north of the smelters, and the Wallaroo to Cowell ferry commenced service in 2006 with its landing immediately across Heritage Drive. Incitec Pivot Ltd have now closed their Wallaroo operations, and are seeking to sell the land. The purpose of this report is to establish which parts of the smelters site are of significant heritage value, and to make recommendations for their future management.

Proceedings

In research for this report, the historical research undertaken by Bannear in 1985 provided an excellent basis, and little additional work had to be done from primary sources. There is fairly good documentation of the development of the smelters, although the early years are less well covered, and it is only from about 1900 onward that the documentary and photographic record becomes more comprehensive. A full bibliography of documentary sources consulted is appended to this report. Inspections of the smelter site were carried out on four occasions: a preliminary reconnaissance in June 2006, detailed recording and survey visits in February and September 2007, and a visit with a surveyor to finalise the boundary in October 2007.

Acknowledgements

The consultants are grateful for the assistance they have received from Scott Nairn of Incitec Pivot, Andrew Nunn of Soil and Groundwater Consulting, Brenton Light of Mosel Browne Surveyors, Greg Drew and Bruno Rescignano of Primary Industries and Resources SA, Paul Stark, Hamish Angas, Chris Giovannucci and Bernadette Irwin of the Heritage Branch, Peter Claughton of the University of Exeter, Mark Taylor of Darley Refractories Australia and Sue Scheiffers of the National Trust.

Plan 1 Survey plan of Wallaroo Smelters site, 2007 (Incitec Pivot)

Wallaroo Smelters: Historical Overview

South Australia was the first place in Australia where metal ores were discovered, and the copper mining industry had its early heyday in the 1840s and 50s following the finds at Kapunda and Burra. As this first generation of mines was beginning to fade, two much larger copper deposits were reported on the Yorke Peninsula of South Australia at Wallaroo (modern Kadina) in 1859 and Moonta in 1861. The district would become one of the world's great copper mining fields.

These new finds were initially worked by two separate companies which later amalgamated. One of them, the Wallaroo Mining Company, established a smelter to treat its ores on the coast at Port Wallaroo in 1861. Initially only rough copper was produced; high grade ore and matte copper were exported for further smelting and refining. Soon however, the company extended its operations to treat all of its own ore as well as feedstock from Moonta and Tasmania. The two mining towns and their port, all connected by railways, became known as the Copper Triangle, and grew to provide an economic powerhouse for South Australia for nearly sixty years. The Wallaroo company also set up a smelting works at Waratah in New South Wales to treat low grade ores sent as backloading on the ships bringing coal and coke from Newcastle.

For nearly thirty years the Moonta and Wallaroo mines were operated by notionally independent companies, although they shared the smelters, the port and the railway network, their shareholders and boards of directors were nearly identical, and they held their board meetings on the same day. In 1865 the Moonta Mines appointed a new manager, Henry Richard Hancock. He and his son would prove to be among the most competent and effective mine managers in Australian history, and between them ran the Copper Triangle for nearly sixty years. The mines were extremely profitable during the boom years of the nineteenth century, and in 1876 the Moonta Mining Company became the first company in Australia to pay a million pounds in dividends. (Flint 1983, p. 2) In 1889 the two companies amalgamated, bringing the whole enterprise under Hancock's supervision as General Manager of the newly-formed Wallaroo and Moonta Mining and Smelting Company, the largest company in Australia.

The smelters operated for 65 years, producing over 300,000 tons of copper metal as well as significant quantities of gold, silver, lead and sulphur-based by-products. They were struggling against falling prices after 1918, but did not finally wind up their operations until 1926. This was a remarkably long-lived and profitable enterprise due to flexible adaptation to changing conditions, responsiveness to new technology, fair work practices, inventiveness, and good management. Its adaptability meant that there was continual and extensive change in the smelters' plant, and by the time the smelters closed, large areas of the site had seen demolition of old structures and erection of new ones more than once in six decades of production.

Wallaroo Smelters: Phases of Development

The most detailed earlier study of the Wallaroo Smelters site was undertaken by archaeologist David Bannear in 1985, and this report relies to a great extent on his historical background and site description (Bannear 1985). Bannear divided the historical development of the smelters into three main phases:

Phase 1 from 1861 to 1889 saw the smelters relying on traditional Welsh reverberatory smelting methods to produce copper from local ores.

Phase 2 from 1889 to 1909 followed the amalgamation of the Moonta and Wallaroo companies. This was a period of technological diversification which saw the introduction of new techniques, treatment and manufacture of commodities other than copper, greater production and greater efficiencies. New plant included waterjacket blast furnaces, an electrolytic refinery, a gold and silver works, a lead works, a sulphuric acid works and copper sulphate plant.

Phase 3 from 1910 to 1923 saw the introduction of converters which meant large savings in time, labour and fuel during the high metal prices of the First World War. The final years saw the smelting works struggling against declining metal prices, and shedding unprofitable operations one by one until the final closure.

This report adapts Bannear's chronological phases to describe the development of the smelters' plant in more detail.

The Welsh Reverberatory Phase 1861 to 1890

Phase One was dominated by the traditional Welsh method of copper smelting which was adopted from the establishment of the smelter in 1861, characterised by the use of reverberatory furnaces. A Welsh reverberatory furnace was a rectangular masonry hearth with a vaulted brick roof over it. Crushed ore or concentrate was mixed with flux and spread on the hearth, and an intense fire was lit in a firebox at one end of the furnace so that the flame passed over the charge on its way to the flue and smokestack. The charge was heated by a combination of direct radiation from the flame, heat reflected - or reverberated, hence the name - from the vaulted roof, and radiation from heat stored in the masonry.

The site chosen for the smelters was right on the seashore beside the landing place, in a position where a limestone escarpment created a natural step about 6m high, which would assist in feeding ore and fuel by gravity to the furnaces on the lower level. Construction of the furnaces began in March 1861, and the first one was fired in a ceremony on 11 November that year. Their flues led to a central stack, a massive brick chimney, square in plan in the Welsh tradition. It was known as Hughes Stack in honour of Walter Watson Hughes, the landowner and director of the mining companies, and his initials were picked out in brickwork on the eastern (town) side of the stack: "W.W.H. 1861".

Reverberatory furnaces had dominated the Australian copper industry since their success at treating the carbonate ores of the spectacularly profitable Burra mine twenty years earlier. But the ores of the Copper Triangle were much more demanding than those of Burra. In common with most Australian copper mines, Wallaroo and Moonta had commenced production from oxidised surface ores like those of Burra, which were rich in copper and easy to treat. The choice of the Welsh reverberatory furnace for the Wallaroo smelters reflected this experience.

But at Wallaroo and Moonta the enriched carbonate ores extended only to a few tens of metres below ground, and below that the copper extended to great depth in narrow vein deposits which were more expensive to mine, they were of lower grade, and much of the ore was in the form of sulphides. These required preliminary roasting to oxidise the ore – that is, remove the sulphur - before reverberatory smelting could be used successfully.

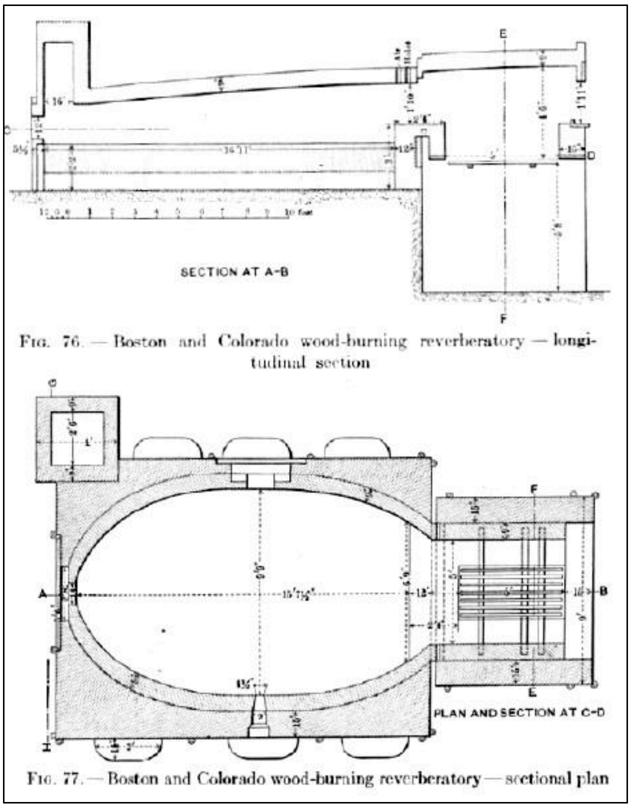


Fig. 76. — Boston and Colorado wood-burning reverberatory — longitudinal section

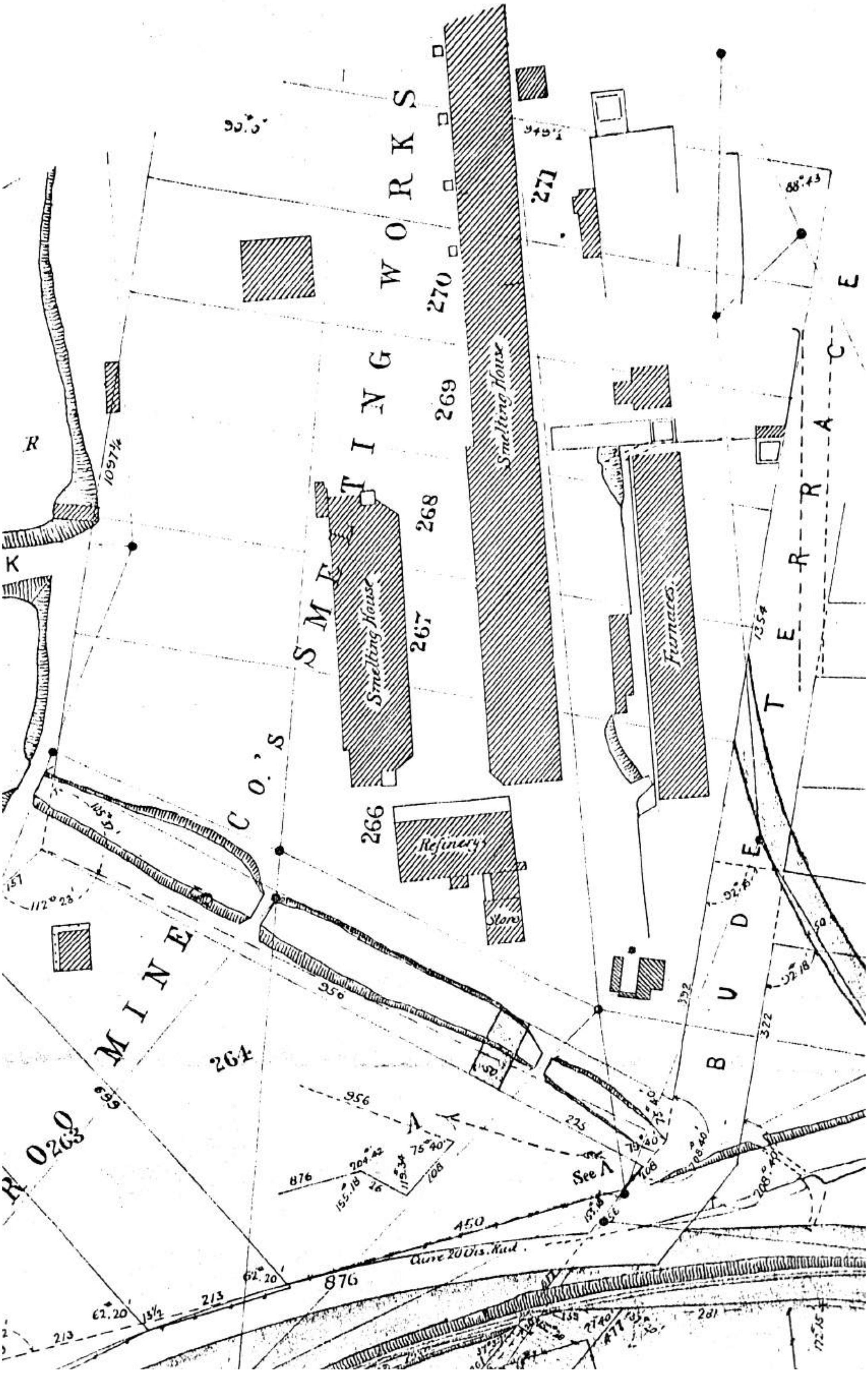
Fig. 77. — Boston and Colorado wood-burning reverberatory — sectional plan

Fig 1 Section and plan of a Reverberatory Furnace (Peters 1911, pp. 391-392)

Before long, calciners were added to the mine plant. The ore was first burnt slowly in these open-topped kilns to reduce the sulphur content of the ore. The product was then crushed and fed to the reducing furnaces in a calculated blend of Moonta and Wallaroo carbonates and sulphides and sinter from the roasting furnaces. The slag from this furnace was tapped off into a sand bed and then used for building or land reclamation purposes. The remaining copper matte was then tapped into sand moulds, cooled and taken to the roasting furnaces. It then passed through a couple of roasting operations to produce slabs of rough copper (known as pigs).

Initially, matte copper - perhaps 50% copper metal with residual copper and iron sulphides - was the final product of the smelters, until in 1862 a refinery with a further four furnaces was added to the works. The rough copper was then transported to the refinery building to be fired yet again, with more precise control over temperature and chemistry to remove impurities. After the slag was poured off, the nearly pure copper was poured into moulds and sent as ingots to the store room for stamping and weighing. With all these processes in use, copper ore from the mine was likely to be roasted at least four times to calcine, smelt, roast and refine it before it was reduced to saleable copper metal. The company's consumption of fuel – coal, coke and firewood - was enormous.

There were a multitude of calciners, roasters and furnaces connected to a complex underground flue system, which was repeatedly modified and rebuilt over time. The early furnaces produced only 60 tons of copper each week, but they were later replaced by larger ones with an output of 150 tons. (*SA Register* 6 October 1923)



Plan 2 Plan of the smelters in the 1880s (*SAPP*)

At first the furnace flues were all connected to the immense central Hughes stack which still stands today, but other stacks were built later to serve distant furnaces. By 1868, seven years after smelting commenced, Wallaroo was being described as "the largest smelting works in the world", although it was to become much larger. There were 36 furnaces of which 22 were reducers, 10 roasters and 4 refineries. The draft went to 13 large stacks and numerous small ones so that the overall effect was a "forest of chimneys". (*SA Register* 25 September 1868) The company was producing on average 4,200 tons of refined copper per year which increased to 6,400 tons per year by 1876. Repairs and maintenance to all these furnaces and flues required the company to import 10,000 firebricks each month.

In 1869 there was an experiment by Walter Watson Hughes to construct new fan-forced or blast furnaces to roast, reduce and smelt the copper in one continuous operation to improve efficiency and save fuel. (*SA Register* 16 May 1870) The idea was years ahead of its time, but it was a failure as insufficient heat was produced by the fuel and blowers available.

The Diversification Phase 1890 to 1909

Phase 2 followed the amalgamation of the Moonta and Wallaroo companies and lasted until the early twentieth century. This was a period of diversification which saw the smelters radically transformed by the introduction of new technology, greater production and greater efficiencies. Henry Richard Hancock retired in 1898 and was replaced as General Manager by his son, Henry Lipson Hancock, who pursued the modernisation of both mines and smelters with even greater vigour. The development of the smelters pursued a number of themes: (1) more sophisticated methods of dealing with the copper sulphide ores which now made up the entire output of the mines, (2) creating a more highly refined copper product, (3) attempts to capture new markets by expanding into the treatment of silver-lead from Broken Hill and gold from Kalgoorlie and (4) more economical extraction and commercial use of by-product sulphur. New plant added in this period included waterjacket blast furnaces, an electrolytic refinery, a gold and silver works, lead smelters, a sulphuric acid works and copper sulphate plant. One early difficulty – seasonal shortage of water – was alleviated in 1890 when a reticulated water supply was laid on to the Copper Triangle from the Beetaloo Reservoir near Port Pirie.

In 1890 the Smelters Manager, Thomas Cloud, was sent to Europe and America to study the latest advances in smelting copper, gold and pyritic ores. On his return many modifications were made and new technology adopted. Wales was no longer at the vanguard of the smelting industry; most of the innovations came from America, but were based on older European - especially German - technology. Gold was present in the rough copper being produced and this was then treated electrolytically. The expanded gold and silver works treated not only the local ores but also Western Australian gold ores from Kalgoorlie and silver ores from Tasmania. The plant operated as a separate entity until 1902 when the recovery process was integrated into the copper smelting process.

One of the main innovations of the period was to treat the tons of sulphurous flue gases which escaped from the chimney stacks every day. A copper sulphate plant was set up in 1894 using waste products: sulphur dioxide gas and flue deposits. Copper sulphate or bluestone was used for telegraph batteries, pickling wheat, sheep dipping, and spraying vines and fruit trees. However, the market proved fickle and it was thought that more profitable use could be made of the flue dust by extracting copper, so the plant was closed in 1907.

A more ambitious project was to use the sulphur dioxide to produce sulphuric acid, essential to the production of superphosphate as well as in leaching the tailings dumps at the Moonta Mines, in the bluestone plant and in the electrolytic refinery. The acid plant was commenced in 1898 and in production by 1900, using the old but effective lead chamber process, in which the gas was converted to sulphur trioxide, then jets of steam were blown into it in lead-lined tanks. (Singer *et al* 1958) Another company - the Wallaroo Phosphate Company – purchased an area of land along the eastern side of the smelters site from the Wallaroo & Moonta Mining and Smelting Company and established its factory in close proximity to the acid plant. By November 1902, 80 tons of acid was being produced each week. Another agricultural by-product of the treatment works was arsenic, which was sold as a herbicide.

The other major development of this phase was the establishment of a lead works to treat mainly Broken Hill and some Tasmanian ores. Testing commenced in 1894 using a rotating copper calciner; this was successful so five rotating calciners were eventually built to process lead. Two 80 ton waterjacket blast furnaces of American design were constructed by the end of 1899 and the lead plant commenced operations. Due to the falling price of lead and the high cost of producing it, the plant had a short life and was closed by the end of 1902.

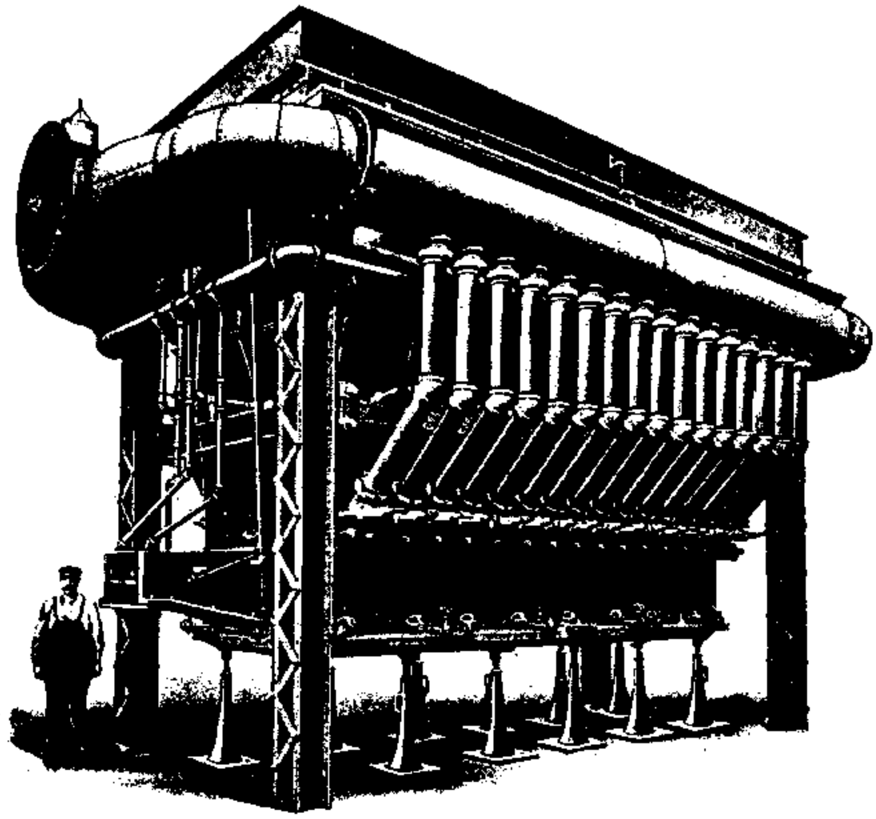


Fig 2 Waterjacket Blast Furnace (Peters 1887, p. 329)

However, the unsuccessful lead experiment was to have a profound effect on the efficiency of the smelters. Early in 1902, one of the two furnaces was adapted to treat copper ores to produce copper matte. Results were encouraging, and by 1903 both blast furnaces had been enlarged and fitted with more powerful blowers, and proved to be very successful at treating copper sulphide ores. The waterjacket furnace was utterly different in operation and appearance from the reverberatory. It was a tall steel box, rectangular in plan and supported by an external frame. It burned coke as fuel, with a powerful air blast raising the ore to white heat. The furnace walls were cooled by water, just as a radiator cools a car engine. The charge was loaded at the top, and slag and matte were tapped at the bottom; both processes were normally carried out while firing continued. It was surrounded by pipes; large ones carrying the air blast from mechanical blowers, and smaller ones carrying the cooling water that circulated through the hollow steel jacket.

The new furnaces were far more efficient than the reverberatories for treating sulphide ores, using far less fuel per ton of ore smelted. Although the waterjacket furnaces still used firebricks, their demand for them was slight in comparison with the tons of masonry that made up a reverberatory. Their waterjacket cooling and robust steel body made for very little down-time, unlike reverberatories they worked continuously, and in competent hands they could be fired for years without ever cooling down. They were also far more forgiving about their charge than reverberatories. Their chemistry was fundamentally different in that the fuel and air blast actively participated in the process, so that previously intractable sulphide ores could successfully be oxidised as part of the matte smelting process.

The two waterjacket blast furnaces were blown-in in June and December 1899. They stood at the northern end of the smelters, on the lower level. A new 150 feet tall stack was built to take their draft, and the horizontal flue leading to it was built into the retaining wall above the furnaces. A new masonry wall was built to house it, and the space between the masonry and the escarpment filled with slag.

The transition from reverberatory to blast smelting was not abrupt or clear-cut. The two processes remained in use side-by-side for over ten years, depending on the ores being treated. It was only after 1910 with the introduction of converters that blast furnaces took the ascendancy.

In 1902, new arrangements were made for handling coal arriving at the smelters. A network of rail tracks was laid into the lower level at the south end of the smelter, on ground that had once been the site of some of the early reverberatory furnaces. An overhead travelling gantry fitted with an electric crane unloaded coal trucks onto an open air coal heap, from which grabs picked it up to load tram trucks to charge individual furnaces.

Other major developments of this time included upgrading the electrical power plant and converting the old lead plant to a much larger new electrolytic copper refinery in 1903. This required a large coal-fired steam generating plant alongside, with its own brick smokestack. Surplus power from the smelters powerhouse was used to provide lighting to the Wallaroo Town Hall and some streetlighting in the town from 1903 onward.

In 1905, the rotating calciners of the lead plant were replaced by three McMurtry sintering pots on the upper level. The McMurtry pots were a new process, invented by the staff at Wallaroo for desulphurising copper concentrates. They were cast iron cylinders 2.6m in diameter and 1.4m deep, fitted with a perforated false bottom or grate. A charge of eight or nine tons of finely-divided ore or concentrate was mixed with fuel such as wood chips or sawdust and ignited. A forced air draft was blown through the bottom of the pot until the charge was oxidised and sintered ready for smelting. (Cloud 1906-07) Another three McMurtry pots were added in 1911.

All these techniques led to increased production and a huge output of slag. A plant for granulating the slag was built; molten slag was poured into seawater and the resulting granules were railed back to the mines and used as backfilling underground. Throughout the life of the smelters, large quantities of slag were also used as a building material on the site. Slag was either poured into iron moulds and used as building blocks, or in some places it appears to have simply been poured onto the ground to form floors.

By the end of 1905, the Wallaroo smelters had almost completely abandoned the Welsh smelting techniques of the early decades. Cloud had made a second visit to the USA in 1898 which had led directly to the erection of the sulphuric acid plant and the blast furnaces shortly after his return. The bulk of Wallaroo's output was now coming from state-of-the-art American technology.

The Converter Phase and Winding Down 1910 to 1923

Phase 3 began with the successful introduction of converters which brought a better product and large savings in time, labour and fuel. Captain Hancock visited the USA in 1909 and commenced the installation of converters at Wallaroo immediately after his return.

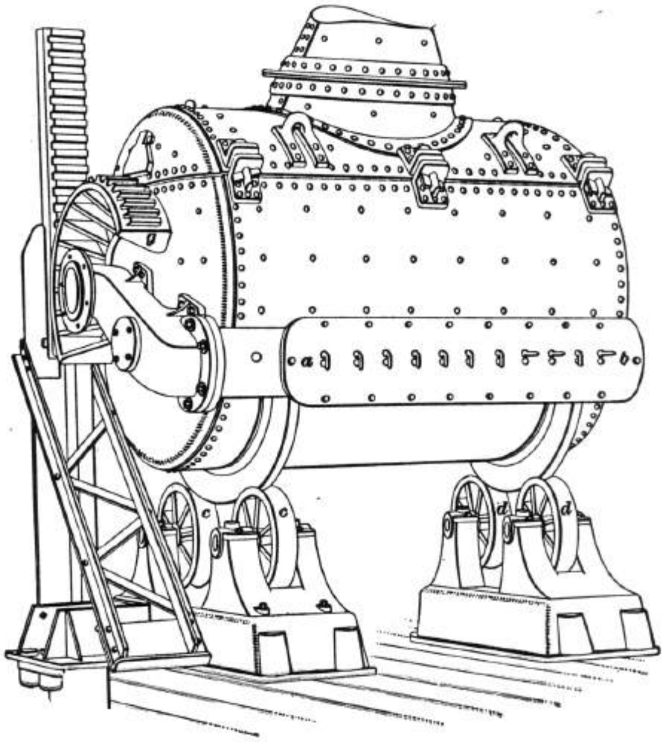


Fig 3 Cylindrical Copper Converter ("Copper Smelting" 1902, p. 54)

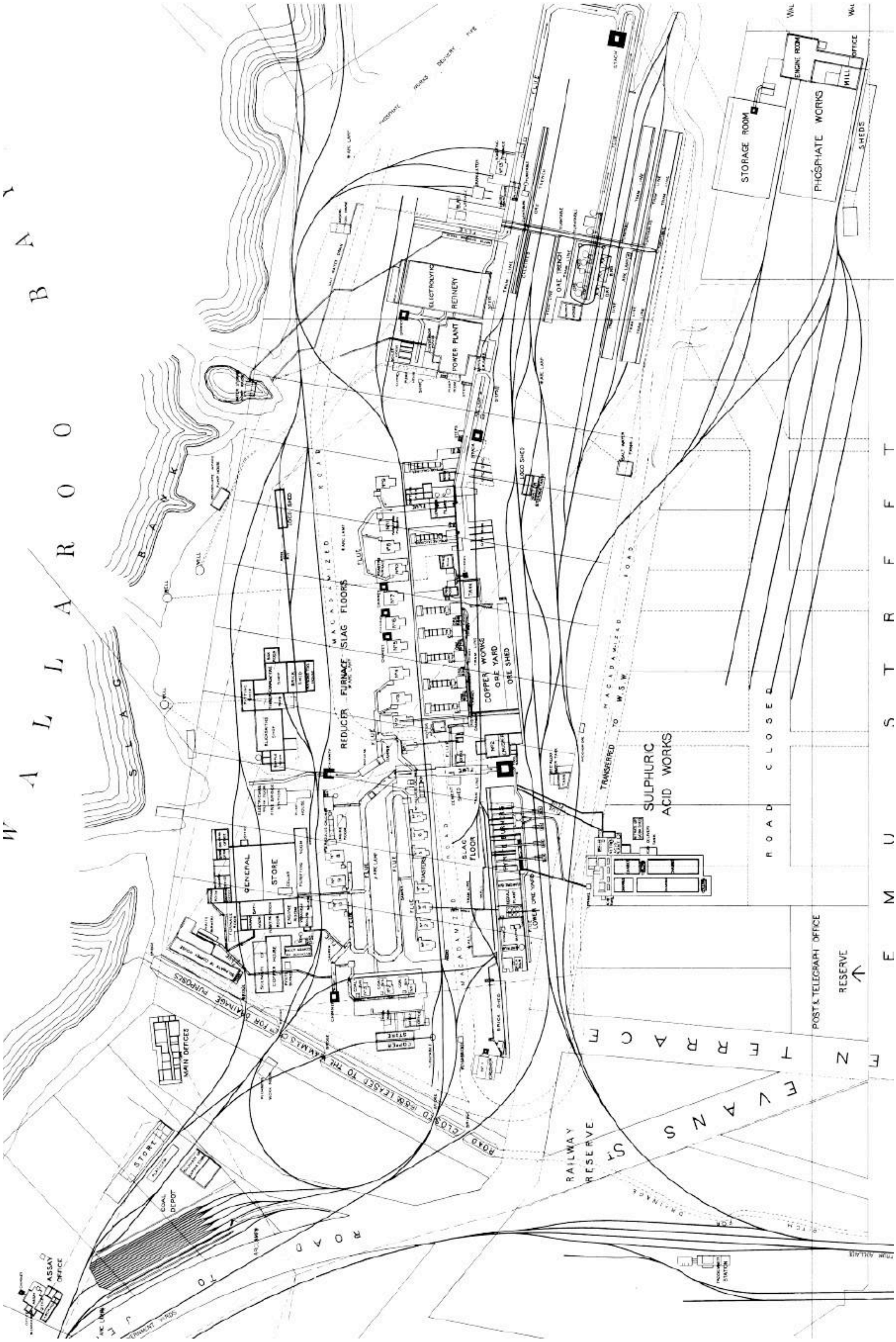
Copper converters were adapted from the Bessemer converter of the iron industry. They evolved out of experiments in both Europe and the USA, and were in full production in large American smelters by the turn of the twentieth century. The converter came between the furnaces and the refinery in the production process, and was charged with the molten matte from the furnace and a silica flux. Transferring the matte while it was still molten made a large energy saving, as previously the copper had been allowed to cool between operations and later had to be re-melted. A powerful air blast was blown through the charge for a few hours, converting the remaining copper sulphide to blister copper with a metal content close to 99%, and slag. The converters were cylindrical in form, and could be rotated to pour off slag and metal in separate operations. Converters were suited only to a few large smelters in Australia, but they were quickly adopted at these. Wallaroo was about the fourth Australian smelter to install them.

The converters commenced operation in August 1910 and quickly made much of the existing plant redundant. They were located beside the blast furnaces on the lower level. The old smelting furnaces (reducers and roasters) were replaced by the converters; some were dismantled soon after 1910 and their bottoms smelted to recover absorbed copper. After the slag had been tapped from the converters, molten copper was cast in moulds in the form of anodes and then taken to the electrolytic refinery. Recovery of gold and silver by electrolysis continued.

The operations at the smelters had been steadily moving north over the years, and most of the early stacks and furnaces at the southern end of the site had been demolished by the early twentieth century. From the multiple operations in small reverberatory furnaces that had characterised the first four decades of smelting, ore treatment at Wallaroo was now streamlined down to essentially three steps: blast furnace, then converter, then electrolytic refinery. By 1910, the old Welsh processes had been entirely replaced by American methods.

But no amount of modern technology could protect the company against the combination of depressed world copper prices, declining ore quality and increasing fuel and mine pumping costs which were looming in the future. The First World War brought an end to the old copper industry. Its early effects for the mining industry were positive, a shortage of munitions in 1915 raising demand for base metals and bringing a boom in copper prices and a period of prosperity. The four years from 1915 to 1918 were probably the most profitable in the life of the Wallaroo smelters. All over the world, copper mines were taking advantage of the demand by increasing production, and governments were stockpiling copper metal. They produced too much and stockpiled too much, and by 1917 the copper price had already peaked. The Armistice of 1918 which ended the period of artificial demand saw prices falling and a glutted metal market, and by 1920 the entire world copper industry was in trouble. The Moonta and Wallaroo mines had survived disastrous price crashes before in 1877 and 1907, but now the mines were down to 1,000m below ground, production costs were high and all the ore bodies were patchy and falling in grade.

From 1918 the company was battling to keep its sixty-year-old mines open. Peripheral operations at the smelters were shut down one by one, and underground mining contracted to the richest ore pockets available. A change in the industrial award in 1919 further hampered the company's efforts; previously wages were indexed to the copper price so that they fell when business was bad, but now they were linked to the cost of living, so they kept rising as the company's income fell. Copper production became irregular in the final years, as the ore supply from the mines was becoming erratic, making it difficult to blend ore grades, and at times in 1922 and 1923 the smelters were closed by industrial disputes.



Plan 3 Plan of the smelters in 1906 (PIRSA)

There was one last technological change. On a visit to the USA in 1919 Hancock was impressed by the efficiency of pulverised coal as a fuel for blast furnaces and steam boilers, and on his return he began work on a coal pulverising plant to lower fuel costs. But the work dragged on for two years, with the company unable to find the specialist builders and bricklayers needed, and the plant remained unfinished when the smelters closed.

The company struggled on, hoping for a rise in the copper price, until October 1923 when the directors accepted that the future was hopeless. They voted to stop the mine pumps and go into liquidation. In 62 years the smelters had produced 332,600 tons of copper metal valued at £20,365,000 plus large quantities of other valuable minerals. Indeed, while the figures are difficult to calculate, it has been said that the value of the gold from the Moonta Mines ores alone paid for the cost of all the smelters' operations.

There is a legend, repeated in local histories, that the Wallaroo and Moonta Mining and Smelting Company failed because the workforce refused to accept a voluntary cut in wages. That might have been the local issue uppermost in some directors' minds at the time of their last meeting, but it was not the reason their company collapsed. The economic facts were simple: in 1923 it cost the company £80 to produce a ton of copper. (*SA Register* 10 November 1923) The average price paid for a ton of copper in London that year was £65. The restructured global economy had destroyed the demand for copper, and was forcing mines and smelters to close all over the world. Even if the miners had agreed to work for no wages at all in 1923, the company would inevitably have failed soon afterwards.

Destruction of the Smelters 1923 to 1926

The closure of the mines at the end of 1923 was not quite the end at Wallaroo. The smelters kept going for a further three years, smelting stockpiled ore and concentrates and stripping the site of anything of value. Machinery and building materials were sold, brick chimney stacks were dynamited, the surviving old furnaces were demolished, and their bricks put through the blast furnaces to extract the few pounds of copper they contained.

In August 1925 hundreds of spectators gathered at the site to watch as the tallest chimney stack at the smelters, built in 1899 to take the draft from the blast furnaces, was brought down by a gelignite charge. (*SA Register* 20 August 1925) By the time the company abandoned the site at the end of 1926, most buildings and structures had been demolished, and everything made of metal or other salvageable materials had been removed and sold.

> The smelting works is a pathetic picture compared with the hive of industry it presented a few years ago. Old buildings, chimney stacks, machinery and plant have been levelled to the ground, in order that the materials may be converted into cash. There is still a good portion of the buildings and plant remaining, and some of these, it is understood, have been sold as they stand, and the buyers will remove them at their own convenience. Smelting operations have now entirely ceased, and the remaining furnaces demolished. Huge heaps of slag and furnace materials are stacked at the works, but as the copper contained in this material is practically nil, the materials are for the time being worthless. (*SA Registe*r 12 January 1927)

The only thing of any size still standing was Hughes Stack, dating from the smelters' very beginning in 1861. It had deliberately been left as a monument.

> The big stack as it is familiarly known in Wallaroo, also bears the letters "W.W.H. 1861," a memorial to the late Sir Walter Watson Hughes, who was so closely associated with the discovery and development of the mines. It is hoped that the old stack will ever remain. (*SA Register* 20 August 1925)

The demolition of the smelters extended over years. An aerial photograph of Wallaroo in 1930 shows two large buildings - the workshops and converter shed - still standing. It also shows masonry remains of furnaces and flues which are now gone. (Fig. 23, p. 26)

When the company's liquidators had gone, the public moved in. Fossickers dug in the furnace foundations looking for missed lumps of copper. For the next sixty years the smelter site was a source of building materials and odds and ends for the local community and anyone else who wanted to help themselves. The few remaining buildings were demolished, and most useful stone and brick was removed from the site. Much of what was left was of irremovable mass concrete or poured slag. It was not until about 1980 that the site was fenced and public access was restricted.

The Fertiliser Factory

The Wallaroo Phosphate Company had commenced production in 1900. The manufacture of superphosphate fertiliser was important to the productivity of the wheat industry, one of South Australia's biggest export commodities. The process involved dissolving phosphate rock in concentrated sulphuric acid. For the next twenty years the factory worked in close cooperation with the smelting company, purchasing its sulphuric acid and electricity, and apparently sharing assay laboratory facilities. While production at the smelters was winding down in the early 1920s, the smelting company offered to sell the acid works to the superphosphate company, but the asking price was apparently too high and the acid plant was demolished. In any case, with all of South Australia's copper mines closing, the factory would have had to source its sulphide feedstock from somewhere else, such as Mount Lyell in Tasmania.

With the smelters and the acid plant gone, the fertiliser factory had to buy its sulphuric acid from other suppliers interstate. It also had to build its own powerhouse and laboratory in the 1920s to replace the services it had previously obtained from the smelters. The fertiliser company bought the former smelters site in the 1950s and demolished nearly all the smelter elements remaining on the upper level to make way for larger store sheds. They did some demolition on the lower level, but made relatively few changes there. A roadway was cut through the escarpment connecting the levels.

The fertiliser factory remained in production for nearly seventy years after the smelters closed, and expanded greatly in size over the decades. It changed hands or was subject to company amalgamations and takeovers on several occasions, operated by the Wallaroo Phosphate Company from 1900, Wallaroo-Mount Lyell Fertilisers from 1913, Adelaide and Wallaroo Fertilisers from 1965, which became Top Australia in 1987 and merged to form Incitec Pivot in 2003. (Wiltshire 1983, p. 133; company and LTO searches) By the 1990s on-site fertiliser manufacture had ceased, and the plant was operated simply as a storage and distribution facility. It has now closed entirely.

Wallaroo Smelters: Photographic Evidence

The Wallaroo smelters were frequently photographed at a number of phases in their history. The company appears to have had a policy of recording developments at the smelters, and there are many professional photographs taken between about 1870 and 1914. These include general long views, building exteriors and close-ups of workers involved in the production processes. A particularly fine set of photographs taken between about 1910 and 1914 show most aspects of the smelters at work.

The photographs are especially valuable for historical research, as the smelters are relatively poorly recorded in maps and diagrams. Only two of the company's plans have survived, showing the smelters in the 1880s and the early twentieth century. (Plans 2, p. 7 & 3, p. 13)

However, there are gaps in the photographic record. For example, the surviving photographs do not give much information about either the reverberatories or the blast furnaces, the interior of the sulphuric acid plant, the coal pulverising plant or the air blowers. There seem to be no photographs of the fertiliser factory, although that was operated by a separate company.

These photographs today do not exist as a single collection. Many are held by the Department of Primary Industry and Resources (PIRSA), others by the State Library of South Australia, some by the Wallaroo Heritage and Nautical Museum - which is located in the former Wallaroo Post Office which occupies a corner of the smelters site - some by Incitec Pivot Ltd and a few by the National Trust. Most of the historic photographs reproduced in this report are from the PIRSA collection, which is accessible on the internet at <https://info.pir.sa.gov.au/geoserver/sarig/frameSet.jsp>

The photographs reproduced on the following pages have been chosen to show the overall changes in appearance of the smelters at intervals throughout their life, and also to illustrate some of the major plant items and processes. It is obvious that the smelters underwent great physical change over time. The photographs also show that operations moved generally from south to north over time, beginning with the "forest of chimneys" of the Welsh process furnaces clustered around Hughes stack from the 1860s to the 1880s, then steadily shifting their focus further north to the steel-clad buildings which housed the blast furnaces, converters and electrolytic refinery in the period 1900-1920.

Fig 4 General view of reverberatory furnaces about 1870, looking northwest (PIRSA 035859a)

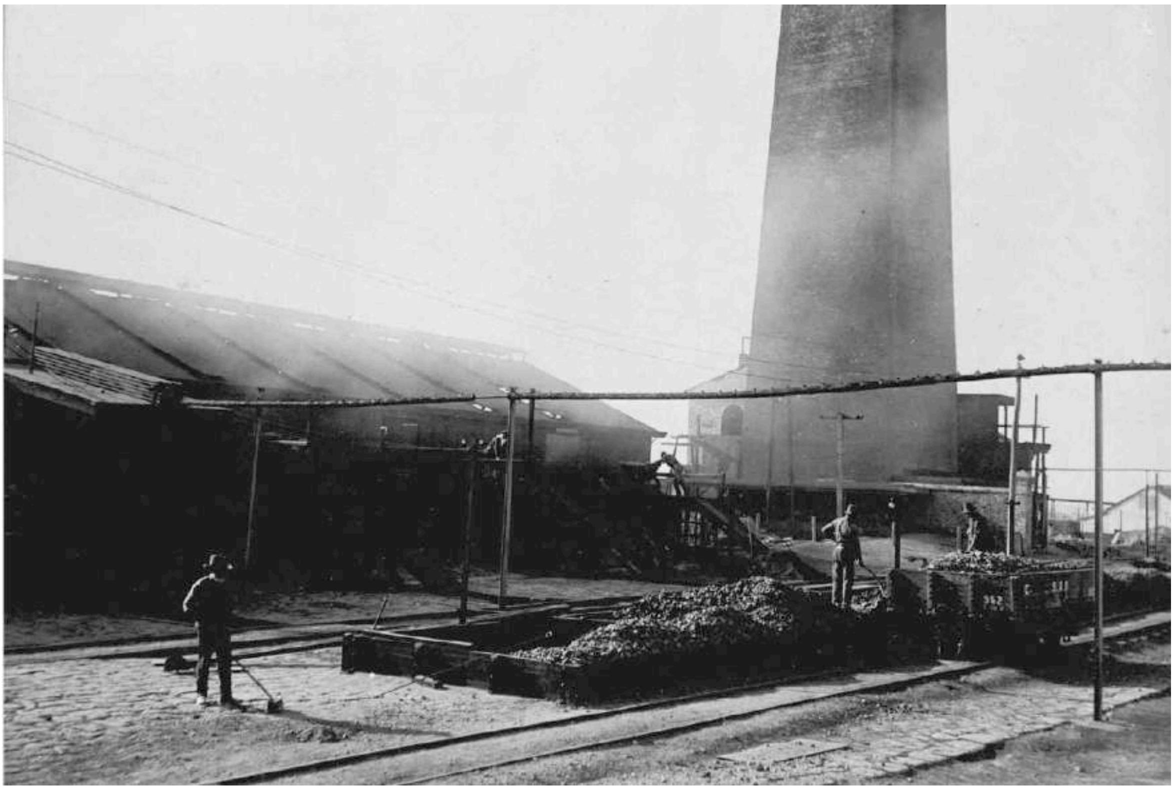


Fig 5 Roasting ore in open calciners near Hughes Stack (PIRSA N020508a)

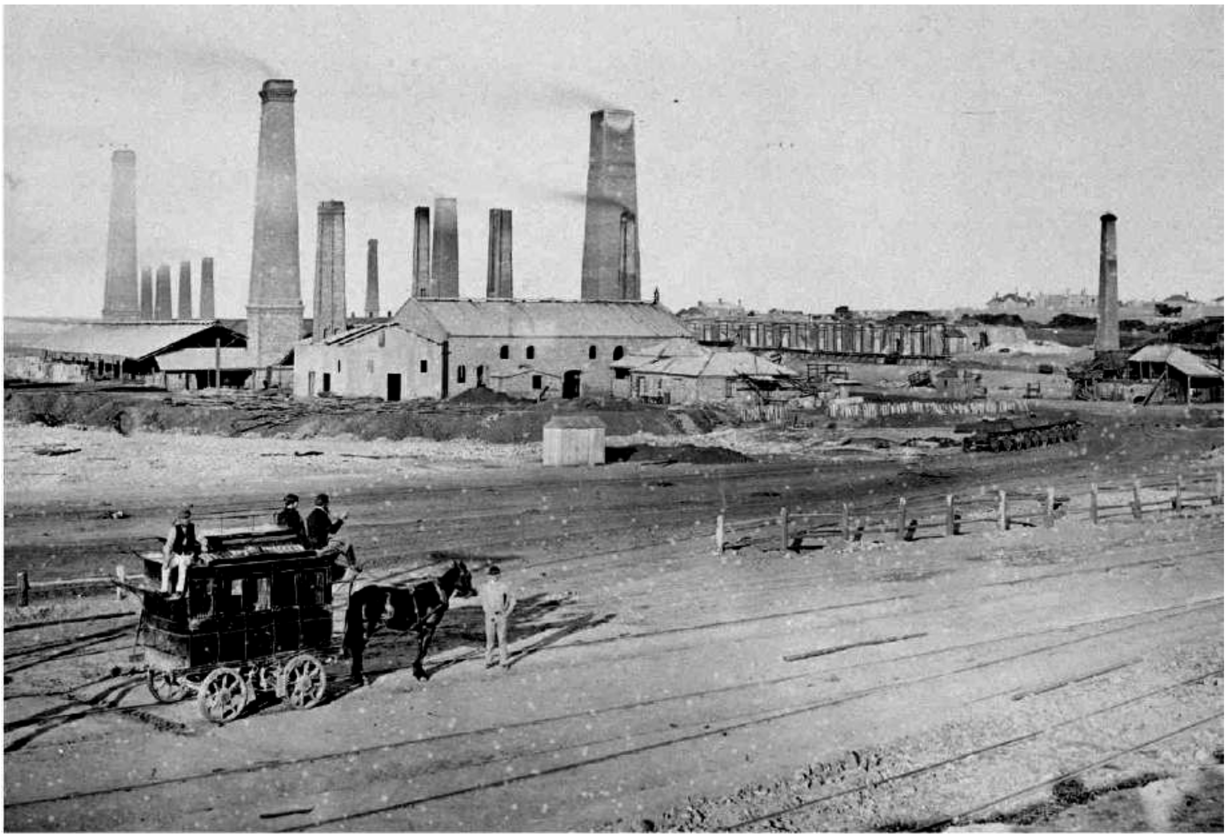


Fig 6 General view of smelters about 1870, looking north (PIRSA N011226a)

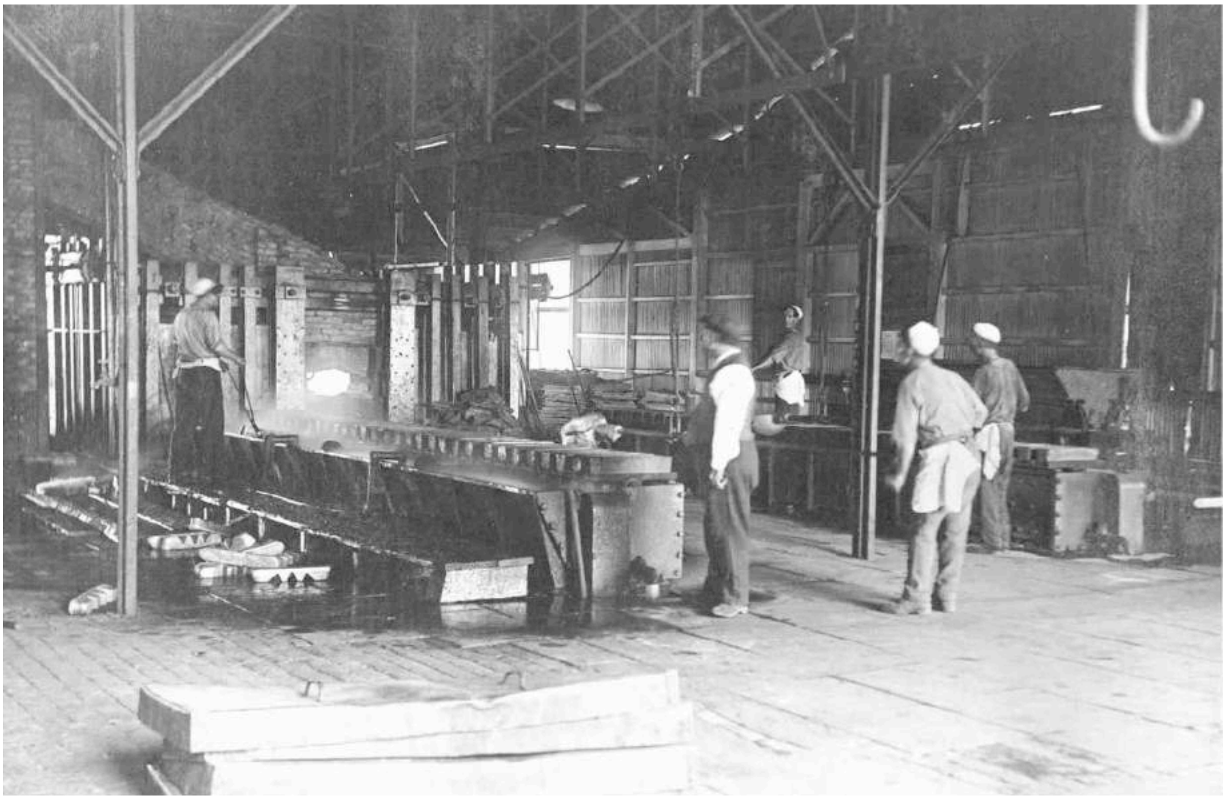


Fig 7 Pouring finished copper ingots from a refinery furnace (PIRSA 044476a)

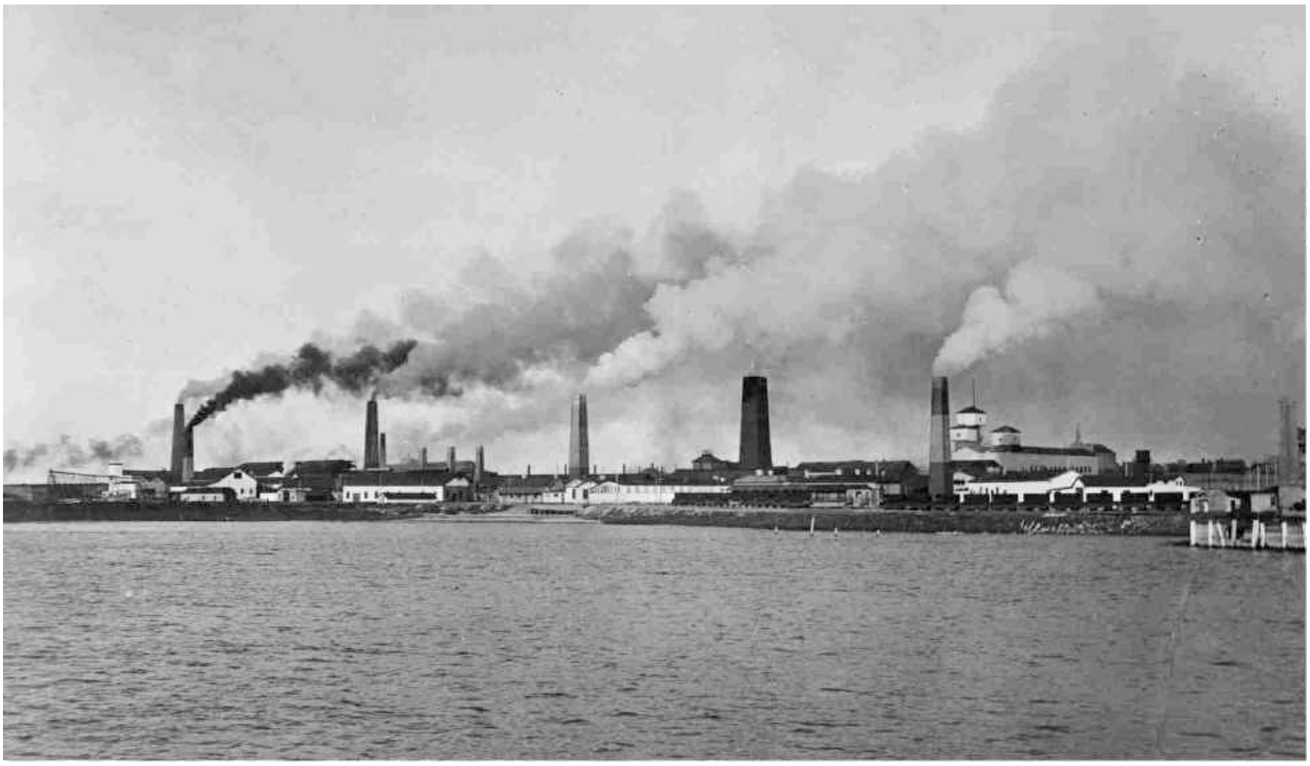


Fig 8 General view of smelters from the harbour 1902, looking northeast (PIRSA N010758a)

Fig 9 Weighing finished ingots in the copper store (PIRSA N020500a)

Fig 10 General view of smelters c.1910, sulphuric acid plant on right (PIRSA N007158a)

Fig 11 Breaking up sintered ore for the blast furnaces (PIRSA 044487a)

Fig 12 Blast furnaces and refinery in the later years, looking north from the roof of the acid works (PIRSA 035859a)

Fig 13 The charge floor, ore and coke being loaded into the blast furnaces (PIRSA N020511a)

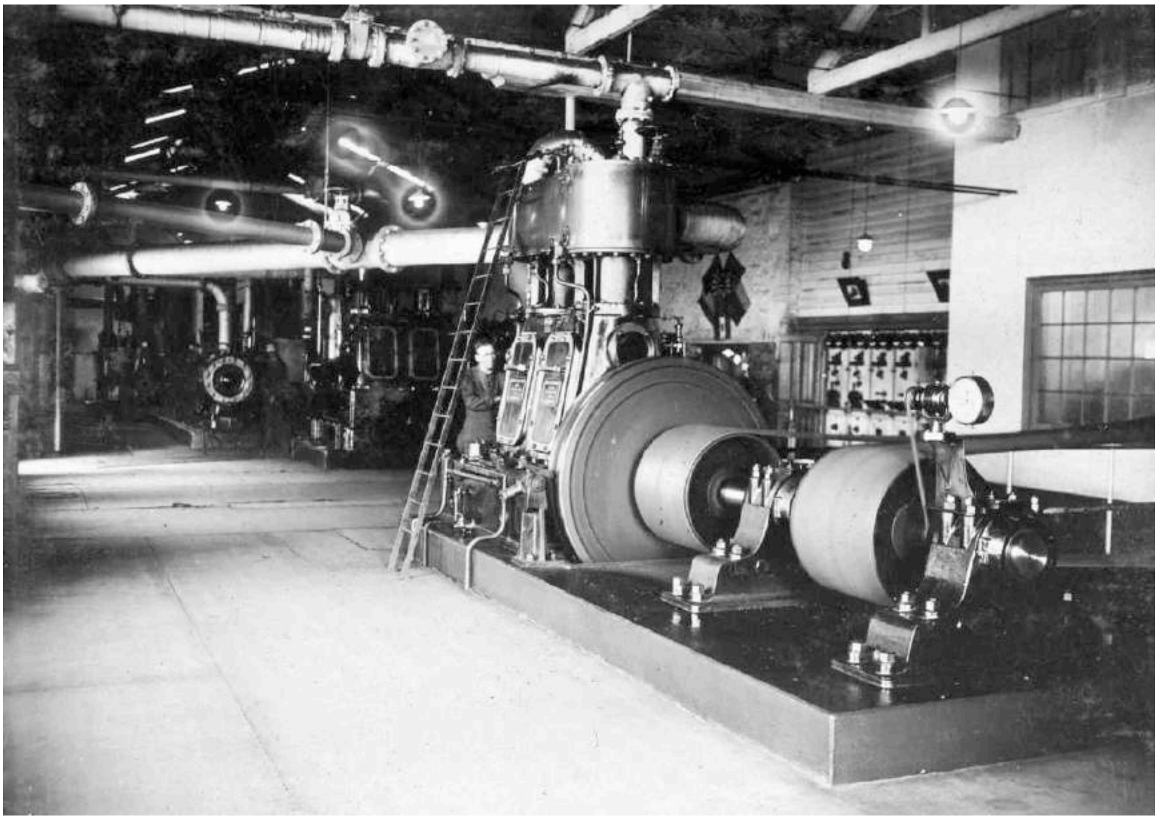


Fig 14 The generating plant which powered the electrolytic refinery (PIRSA N020513a)

Fig 15 Casting copper anodes for the electrolytic refinery (PIRSA N020506a)

Fig 16 The electrolytic refinery, showing rows of anodes in the tanks (PIRSA N020505a)

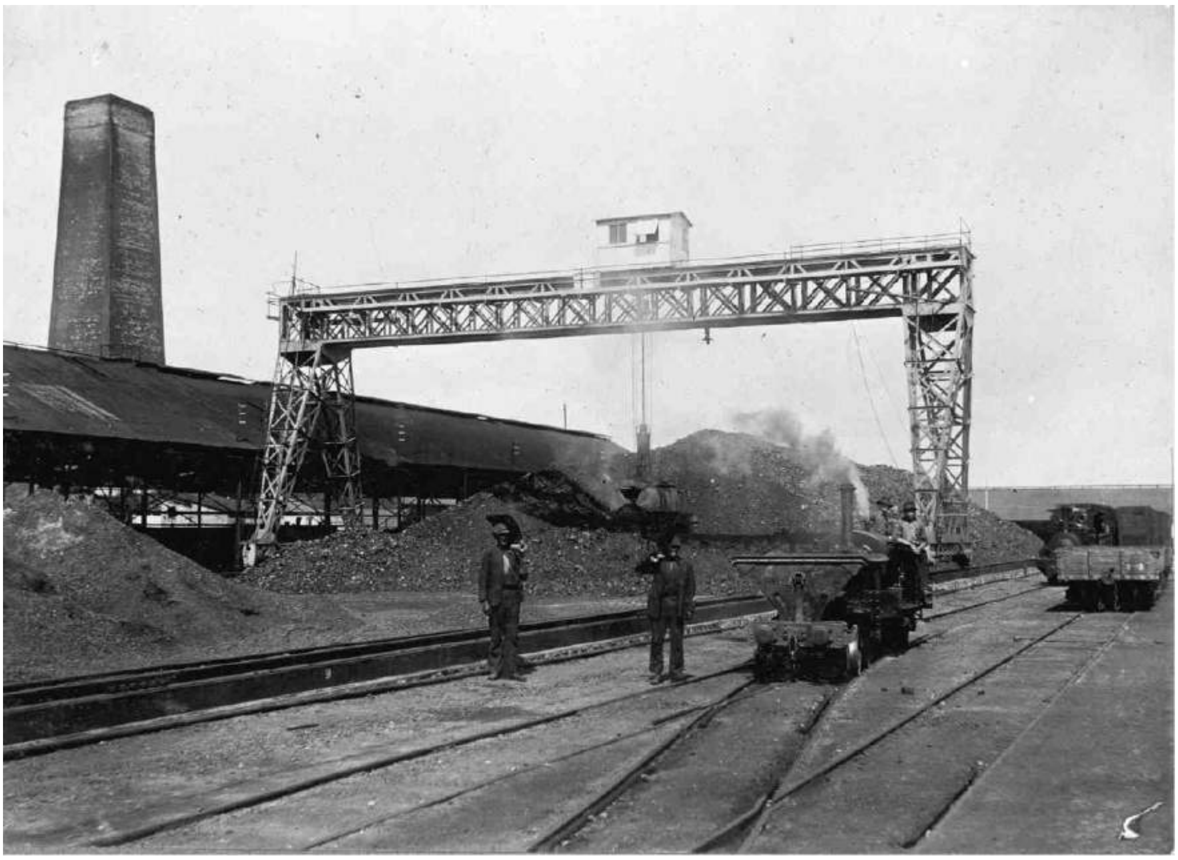


Fig 17 The coal gantry, Hughes Stack at left (PIRSA N020504a)

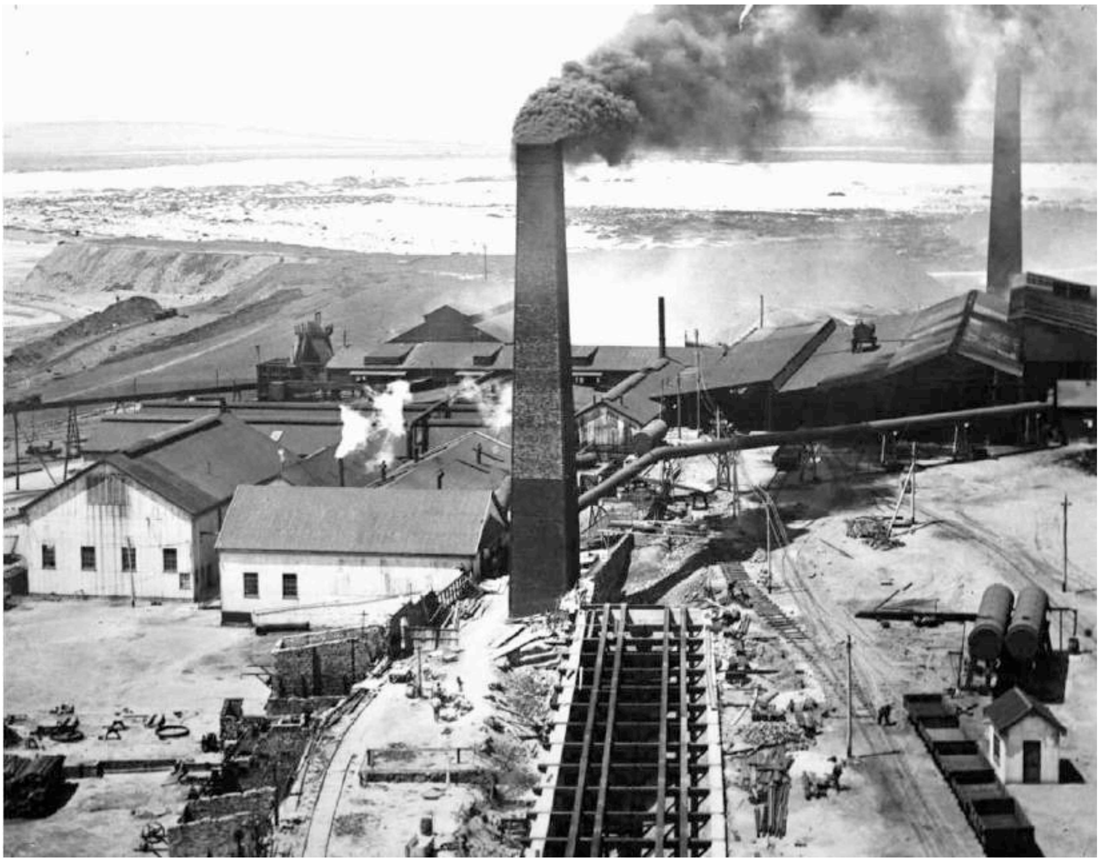


Fig 18 General view of smelters from Hughes Stack in later years: powerhouse and electrolytic refinery at left, converter shed at rear, blast furnaces and sintering pots in large shed at right (PIRSA 038613a)

Fig 19 Breaking up the charge from the McMurtry sintering pots (PIRSA N020512a)

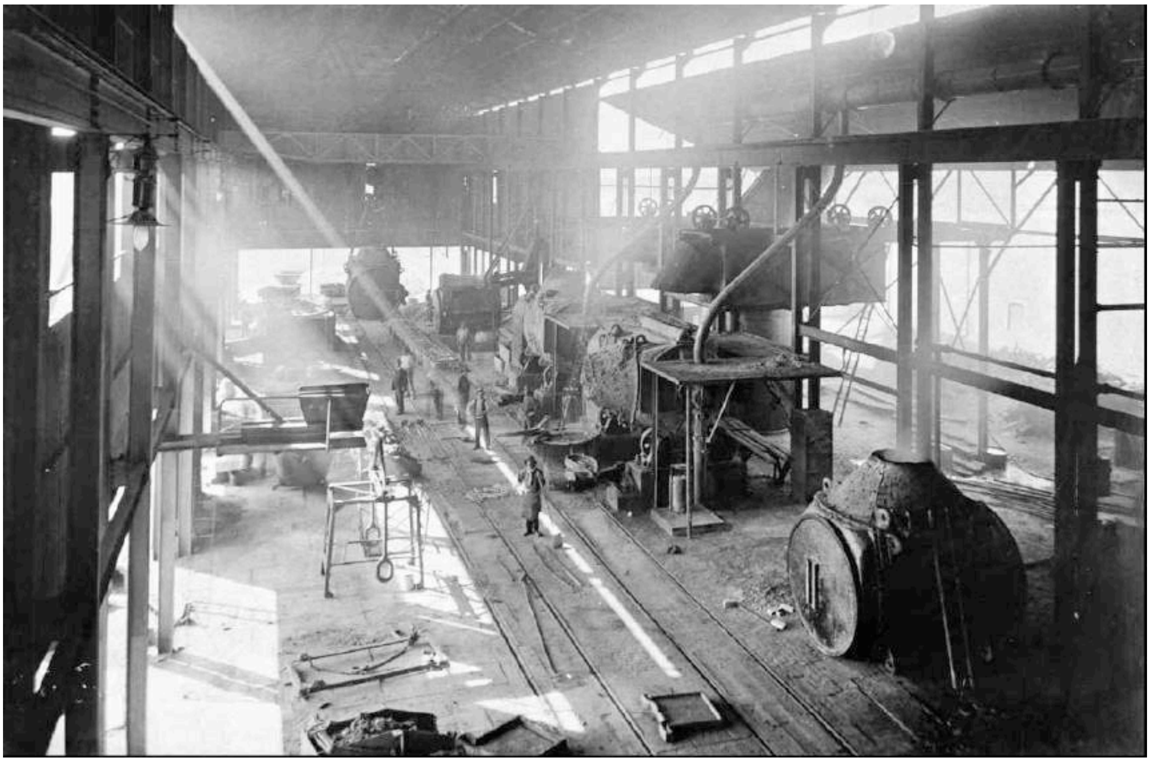


Fig 20 Looking down into the converter shed (PIRSA 034035a)

Fig 21 Pouring copper ingots from a converter (PIRSA N010755a)

Fig 22 The reverberatory furnaces site after demolition (PIRSA N013824a)

Fig 23 Aerial view of the demolished smelters site, looking south, 1930 (PIRSA 038582a)

Wallaroo Smelters: Evidence Surviving from Phases of Development

The field inspections of the smelters site conducted in the course of this project used David Bannear's 1985 plan as their starting point. (Plan 4 on page 49) Bannear's plan is still an accurate guide to the structural remains of the central smelters site, where very little has changed. The photographs taken in 1985 show very little change or deterioration in the majority of structures since; the masonry ruins have stabilised decades ago and are now undergoing very little natural or human alteration. The principal changes since 1985 have been in peripheral areas: (a) the demolition or burial of foundation elements of the mine stores and workshops which extended west of the present project area into what is now public roadway and parking areas, (b) extensive earthworks including the construction of high earth bunds around the fertiliser factory and areas of the north and east of the site (these do not impact significant elements of the smelters), (c) the erection of large new storage buildings adjacent to the fertiliser factory, and (d) the removal and re-distribution of a large amount of granulated slag, which is discussed below.

Not much remains of the Wallaroo smelters. We can see this from the historic photographs on the preceding pages – most of the buildings and structures in the photographs are simply not there today – at best we can recognise foundations and fragments. The company's thoroughness in stripping the plant and site of all saleable materials has left very little standing above ground. The surroundings are dominated by Hughes Stack, the oldest thing on the site, the first chimney built at the smelters and the single surviving one from the "forest of chimneys" which once stood there, deliberately left as a monument. No other standing structures remain from Phase 1 of the smelters' development, 1861 to 1890. There is an extensive area of underground furnace flues and foundations to the west and south of Hughes Stack which are from an early date, but this has been subject to so much demolition and rebuilding that it is difficult to interpret in detail.

The site is divided into two by the break in levels, defined by the retaining wall which runs along the escarpment for much of the length of the site, a distance of about 500m. Almost all the significant ruins of buildings and structures are located on the lower side, or west of the retaining wall. Relatively little remains on the upper or east side, where the processes of demolition and removal took place over a much longer period and were much more thorough.

Not surprisingly, much of the remaining evidence in the form of building ruins and foundations dates from the processes in use relatively late in the life of the smelters, so that the evidence of the form of the smelters at the time of their closure in 1923 is fairly easy to read. The sites of structures abandoned early in the life of the smelters have mostly been obliterated by later construction on the same site.

The north-west corner of the site is dominated by large dumps of granulated slag. Large areas of the project area to the north, east and south of the fertiliser factory buildings contain no buildings or structures of historical interest.

The following notes briefly describe the principal surviving elements of the smelters They can be followed by reference to Plan 6 on page 51.

Hughes Stack (Figs. 25, 27 & 28, pages 35 & 36)

The largest and best-preserved single remnant of the smelters on the site is Hughes Stack, built of brick, square in plan in the Welsh tradition, and 120 feet (36m) high. There are over 200,000 bricks in the stack. It is the oldest structure surviving from the smelters, built to serve the reverberatory furnaces in 1861. It demonstrates Walter Hughes' pride in his achievement, as it is emblazoned with his initials and the date. It was deliberately left standing as a memorial when the smelters were being demolished in 1925. It is one of the few historic elements of the smelters which survive on the upper side or east of the retaining wall. The stack has been a major landmark for 147 years, a beacon for shipping in Spencer Gulf, and appears in many historic photographs of the smelters. It is the largest historic chimney remaining in South Australia, and is entered in the Register of the National Estate. The National Trust holds a photograph which shows that the main flue entering the stack was still intact in the 1970s. The stack is now in good condition, having had extensive conservation work, including bracing with an external steel frame, in recent years.

Fig 24 Hughes Stack, looking east, April 1975. The section of flue visible in the foreground was demolished before 1985 (National Trust file 1834)

Escarpment Retaining Wall (Fig. 29, page 37)

The retaining wall bisects the site, running 500m from north to south through the heart of the smelting areas, over 6m high at its northern end, but gradually diminishing in height as it goes south. It was an element of the smelters' design from the beginning, taking advantage of a natural escarpment or change in level of the site both to allow gravity feed of ore and fuel from the upper level to the furnaces below, and to assist the draft of the stacks on the upper level. It retained its usefulness throughout the life of the smelters, and in the later years the blast furnaces were located with their tops at the level of the wall, and were fed from the charge floor above.

The wall is not conspicuous in historical photographs of the smelters, as it was almost entirely concealed by furnaces, flues and buildings in close proximity above and below it. Only since the demolition of those furnaces and buildings in the 1920s has it become visually prominent. The wall was built in stages over four decades, and is made of a number of materials: partly stone, brick, cast slag blocks and poured slag. It is pierced by many openings into flues and other spaces behind. Ore chutes and furnace flues can be identified. In places the wall is in fact two parallel walls with a furnace flue incorporated between them.

The wall changes direction by about 15° to the east a little north of its halfway point, presumably reflecting a bend in the natural escarpment underlying it. Everything north of the bend dates from after 1899. The change in direction corresponds to the evolution of the smelters' technology over time, with most of the nineteenth century furnaces south of it, and most of the post-1900 structures to the north. There is a gap in the wall at the bend, with a vehicle track connecting the two levels. There was no such gap when the smelters were in operation; indeed the 1906 plan shows a railway line running along the top of the wall at that point. The track was cut by the fertiliser company in recent decades.

The condition of the wall varies; in some places it is solid and appears structurally sound, built of slag, which is an extremely durable building material. In other places the masonry has collapsed, and the wall face is an unstable earth bank. The wall has been used as a rubbish dump in recent decades, with building materials and other debris dropped over it so that they become invisible to people on the factory level above, but are unsightly to passers-by below.

Reverberatory Furnaces (Figs. 1, page 6; 32, page 38)

The Welsh reverberatory furnaces were at the heart of the smelters' operations for the first forty years, but all of them have been demolished, leaving very little trace above ground. The furnaces were built of brick and came in a variety of sizes and shapes, depending on whether they were designed for roasting, calcining, reducing or refining. The total number of furnaces built at Wallaroo is unknown, but probably very large. We know there were 36 furnaces standing in 1868, but many others would have been built and demolished before and after that date. The working life of a reverberatory furnace was relatively short because of the thermal stresses it suffered in cycles of heating and cooling, and furnaces were constantly being repaired and rebuilt; in their heyday the smelters were importing 10,000 firebricks a month. There were dozens, perhaps hundreds of furnaces built on the smelters site over the years.

The principal legacy of the furnaces is below ground. Historical photographs show that most of the furnaces and all their stacks except Hughes had been demolished well before the smelters closed, as the blast furnaces and converters had taken over their role. (The number of bricks involved must have kept the building industry of the Copper Triangle supplied for many years.) However, no-one took the trouble to dig up the thousands of bricks which were laid in the foundations, underground flues and tunnels beneath many of the furnaces. There is an area of perhaps two hectares below the retaining wall to the west and south of Hughes Stack where historic plans show most of the furnaces were located. In that area today, natural subsidence and modern excavations show numerous brick-lined cavities. The extent and layout of these underground structures are unknown, and it would be an enormous task to investigate them archaeologically.

Sintering Pot Bases (Figs. 19, page 24; 33, page 39)

Above the retaining wall toward the northern end of the smelter site is a row of seven large reinforced concrete blocks, which stand over 2m above present ground level. These are the foundations of the six McMurtry sintering pots which were installed between 1905 and 1911. They are of particular interest as a rare, perhaps unique, piece of technology, and also because they are one of the few surviving structures on the smelters site which can be recognised in a historical photograph. (See Fig. 19, page 24) The photograph shows that these blocks are in fact about 4 to 5m in height, so about half their height is apparently underground at present.

In 1905 three McMurtry pots were installed to "desulphurise" the ore, which meant to oxidise it by roasting. McMurtry sintering pots were new to the industry. They had been developed at the Wallaroo smelters between about 1903 and 1905 for desulphurising copper ore in what was known as the McMurtry-Rogers process. The process was derived from the Huntington-Heberlein process used for treating silver-lead sulphide ores. (Huntington & Heberlein 1906)

The McMurtry pots were of cast iron, slightly tapered cylinders 2.6m in diameter and 1.4m deep, fitted with a perforated false bottom or grate. A charge of eight or nine tons of finely-divided ore or concentrate was mixed with fuel - McMurtry and Rogers recommended sawdust - and ignited. A forced draft of 1,000 cubic feet of air a minute was blown through the bottom of the pot. The charge was oxidised and sintered in about twelve hours, ready for smelting. (Cloud 1906-07) The initial battery of three pots seems to have been very successful, and three more were added in 1911.

There were apparently only two smelters in Australia where they were used: the Wallaroo smelting works where they were a success, and the small smelter at Mount Cannindah in Queensland, where the mine failed in 1907 while they were still being tested. There is no surviving trace of the Mount Cannindah pots. (Bell 2007)

The principal inventor, George Cannon McMurtry (1867-1918), was a metallurgical engineer and graduate of the Royal School of Mines who lectured briefly at the South Australian School of Mines in 1890, was deputy manager of the Wallaroo smelters from 1891, acted as manager at times between 1903 and 1907, and subsequently worked in New Zealand. He has an entry in the *Dictionary of New Zealand Biography*. His junior colleague Rogers seems to have faded into the mists of history.

In addition to the photograph, there is an eyewitness account of the pots in use. Perce Chynoweth went to work at the Wallaroo smelters in 1905. Late in his life he wrote his reminiscences, which were published by the Wallaroo branch of the National Trust. He described what he called the "cindering pots":

> The pans were shaped like a huge basin about eight feet in diameter and five feet deep. At the bottom was fitted an arched plate with holes to keep clear the entrance hole for the air blast coming from a large fan with many blades. (Chynoweth 1975, pp. 6-7)

He went on to describe how each pot was inverted, allowing the charge to drop out onto the floor beneath. It was broken up manually and sent to the smelter. The photograph taken in about 1914 shows the process of manually breaking up the charge and shovelling it into hopper trucks. The pots and their air manifolds can be seen high above the men on the floor. The concrete supports between the pots are hidden in shadow.

Blast Furnaces (Figs. 2, page 9; 35 & 36, page 40)

The blast furnace building, like the converter house, electrolytic refinery and power station represent the last generation of processes operating at the time the smelters closed All the processing plant and the buildings were demolished and taken away for scrap in 1926, but nothing has happened on their sites since, so the floors and in some cases concrete machinery foundations are still recognisable.

The two blast furnaces installed in 1899 were free-standing structures of steel and brick which would have been demolished for their scrap metal value in 1926. (See Fig. 2 on page 9) All they required was a level floor to stand on, and that concrete floor can still be identified at the foot of the retaining wall near the northern end of the site. It is covered in a litter of stone, concrete and brick building rubble, but no furnace parts can be identified.

Charge Floor (Figs. 13, page 21; 34, page 39)

On top of the retaining wall, 6m above the blast furnace floor, is another level concrete floor extending to the edge of the drop. This was the charge floor, where the furnace charge of copper ore, coke and flux was wheeled in iron trucks and manually tipped down chutes directly into the furnaces.

Converters (Figs. 3, page 11; 37, page 41)

West of the blast furnace area are a series of concrete foundation blocks fitted with machine bolts. These were the bases of the two converters installed in 1910. The building that housed them, and associated railway lines and other structures shown in historic photographs are gone without trace.

Power House (Figs. 14, page 22; 38, page 41)

The electricity generating complex was installed in 1903. It consisted of boilers, a tall brick smokestack, steam engines and DC generators whose principal function was to provide current to the electrolytic refinery, but also powered electrical machinery such as the coal gantry and converter house gantries, and provided electric lighting to the smelters and the town of Wallaroo, A photograph of the generator room shows it was the cleanest place in the smelters (Figs. 14, page 22). The whole complex was demolished in 1926 and the fertiliser factory built a new diesel powerhouse on a new site in 1929. What remains on the site today is an area of concrete floors and some heavy concrete machinery foundations, which presumably supported the steam engines and generators.

Electrolytic Refinery (Figs. 16, page 23; 39, page 42)

The electrolytic refinery operated from 1903 to 1926. It was a large open shed almost filled with tanks of electrolyte. Blister copper anodes were suspended in the tanks, and passing a current caused them to be deposited as cathodes of refined copper. Gold and silver were also refined by electrolytic processes. The remains of the refinery building today consist of an open space with fragments of concrete flooring, partly surrounded by a wall of slag blocks.

Coal Pulverising Plant (Fig. 40, page 42)

The coal pulverising plant represented the Wallaroo smelters' last struggles to remain viable by keeping costs down. The plant was commenced in 1921 in an attempt to use finely-divided coal in an air blast as a more efficient fuel for the furnaces The company had difficulty finding the specialised labour and materials necessary, and the plant remained unfinished two years later when the company was liquidated. The remains consist of concrete machinery foundations, and two tall hollow concrete columns, which are conspicuous elements in the centre of the smelters site just below the retaining wall. The two columns were air lifts, which would have used an air blast to raise pulverised coal to the height of the upper level to fuel the furnaces.

Coal Conveyor (Figs. 41, page 43)

As part of the more efficient fuel regime, an underground conveyor was built in a tunnel running from the coal depot to the pulverising plant. It ran under the railway tracks, with a series of openings in the roof of the tunnel so coal trucks could unload directly onto the conveyor belt below. The concrete structure of the tunnel and some metal fittings remain.

Coal Gantry (Figs. 17, page 23; 42, page 43)

Several photographs of the smelters show the coal gantry, built in 1902 to shift coal in the new central coal depot on the lower level. It was a large steel-framed structure which ran on two wide tracks, its overhead beam fitted with a travelling electric crane which operated grabs. Coal arrived by sea and was stockpiled on the ground between the tracks, from where the gantry operator picked it up in the grabs and deposited it into rail trucks or conveyors as required.

What remains of the gantry are the two concrete foundations for its steel tracks, which extend for about 200m, partly buried in places. They run parallel to the southern section of the retaining wall, about 50m from it and about 25m apart. Completely missing from the scene are the network of railway lines which brought coal to and from the depot.

Slag Heaps (Figs. 43 & 44, page 44)

In the north-west corner of the smelters site is a deposit of granulated slag mixed with soil and building debris. Slag is the waste rock, melted and re-solidified, left after the copper has been extracted by the smelting processes. One of its main constituents is ferrous sulphide, which gives slag its black colour. The Wallaroo slag deposit forms a series of irregular heaps, and some of it has been piled as a bank or bund along the northern perimeter of the site, and disguised on the outside with a layer of earth. What is surprising about the Wallaroo slag deposit is not how large it is, but how small. There should have been something like three million tonnes of slag produced at Wallaroo (Flint 1983), but most of it is missing from the site.

There is a lot more slag remaining at Wallaroo than meets the eye. Historic photographs show that poured or granulated slag was used as landfill to extend the foreshore outward (Fig. 23, page 26), and there must be a large quantity of slag underlying the land forming the gulf coast and seabed to the west and north of the smelters site. In parts of the smelters site the ground underfoot is formed of poured slag, and slag cast as building blocks is found in walls and foundations throughout the site. (Fig. 43, page 44) But these uses only make up a small proportion of the total amount of slag produced at Wallaroo in 65 years of smelting. The vast majority of it must have been railed back to the mines at Moonta and Kadina and used as backfill in the underground workings.

It is apparent from a study of Bannear's site plan that the slag deposits have moved around since 1985. Some of the deposits have been removed altogether (the granulated slag has traditionally been used as road base and for grit-blasting in the past) and what remains has been shifted by earthmoving machinery, most of it to form visual barriers around the smelters site. It is likely that none of the granulated slag is now on the site where it stood when the smelters closed.

Fertiliser Factory (Figs. 45-48, pages 45 & 46)

The largest building remaining on the smelters site is the fertiliser factory, operated by about five different companies over ninety years, and now disused. Or perhaps it would be more accurate to describe it as a series of fertiliser factories, for it is evident that a number of different plants have been built within the complex and later abandoned as the technology of the industry moved on.

The 1906 plan of the smelters shows the "Phosphate Works" as a relatively small building near the northern end of the site. The complex that stands today sprawls over a much larger area. The oldest parts of the factory are at the northern end, and within the complex are two stone structures that correspond roughly, but not in detail, to the building on the 1906 plan. These each consist of a single stone chamber, connected by later buildings. There is no internal plant in either room, and no indication of their functions. Each has been repeatedly modified by cutting new openings and blocking up old ones. They have been abandoned for many years. Around and incorporating them is a series of large industrial buildings, timber-framed and steel clad which extend several hundred metres to the south. The diesel power station built in 1929 is a freestanding steel-clad building near the northern end of the factory complex.

The date of construction within the complex generally becomes later with distance travelled south. All plant and machinery has now been removed from the buildings, leaving large empty spaces, so it is difficult to determine their function. To judge from the techniques of industrial construction, large parts of the complex date from after the Second World War, and large spaces must simply have been used for storage of materials, and loading products onto both rail and road transport.

Two smaller buildings stand at the street entrance to the site, facing Charles Terrace. One is the fertiliser factory office, a building of domestic scale in stone with brick quoins in Federation style. It is of early twentieth century date, but the factory office is shown on another site in the 1906 plan. Beside it is another timber-framed building which was the factory laboratory. It was built in the 1920s after the smelters' assay office closed. On the factory site are modern fuel tanks, office, lunch room, workshops and other small buildings of no historical interest.

Bricks (Fig. 49, page 47)

The Wallaroo smelters site is littered with scraps of building materials: stone, slag, concrete and thousands of bricks, mostly broken. The brandnames reveal a museum of bricks from around the world. Many of them are refractories or firebricks used in furnaces and flues: *Cowen* was the brand of Joseph Cowen & Coy of Blaydon-on-Tyne near Newcastle in the north of England (1823-1903). *Atlas*, *Dougall* and *Gartcraig* firebricks were all imported from Scotland, made respectively by the Atlas Fire Brick Works of Bathgate, West Lothian (1882-1973), James Dougall & Sons Ltd of Bonnybridge (c.1874-1962) and the Gartcraig Coal and Fireclay Coy Ltd of Gartcraig near Glasgow (1872-1927). Bricks marked *Obsidianite* may also be from Glasgow.

Some of the firebricks on the site are of Australian origin: *Watts* firebricks were made by J.S. Watts & Sons at Nairne in the Adelaide Hills (1863-1984), and *Darley* firebricks came from the Darley Fire Brick Company which began manufacturing refractories at Bacchus Marsh in Victoria in 1893, and still operates today as Darley Refractories Australia Pty Ltd. There are also large numbers of unidentified firebricks marked simply with numerals and letters, e.g.: *39 77 C1 B*.

Then there are common red house bricks, most of them unmarked. Some marked *Bakewell* were made by Bakewell Brothers of Erskineville, NSW (1884-1955). Others marked *Federal* are from the Federal Steam Brick Works at Waratah near Newcastle. (1901-1914). These almost certainly arrived at Wallaroo with cargoes of coke. (Gemmell 1986, Gurcke 1987, Moore 1981, Sanderson 1990, Watts 1985)

Throughout the life of the smelters there was a brickworks making bricks locally, and by 1902 they were said to be producing 70,000 high quality firebricks each year. (Bannear 1985, p. 85) These must have been unmarked, as no Wallaroo brick brand has been identified on the site.

Fig 25 General view of the smelters site from south-west, Hughes Stack at centre, foundations of store extending under boundary fence in foreground

Fig 26 Much of the project area consists of bare ground and modern earthworks

Fig 27 Hughes Stack from north-west, looking up from reverberatory furnace sites on lower level

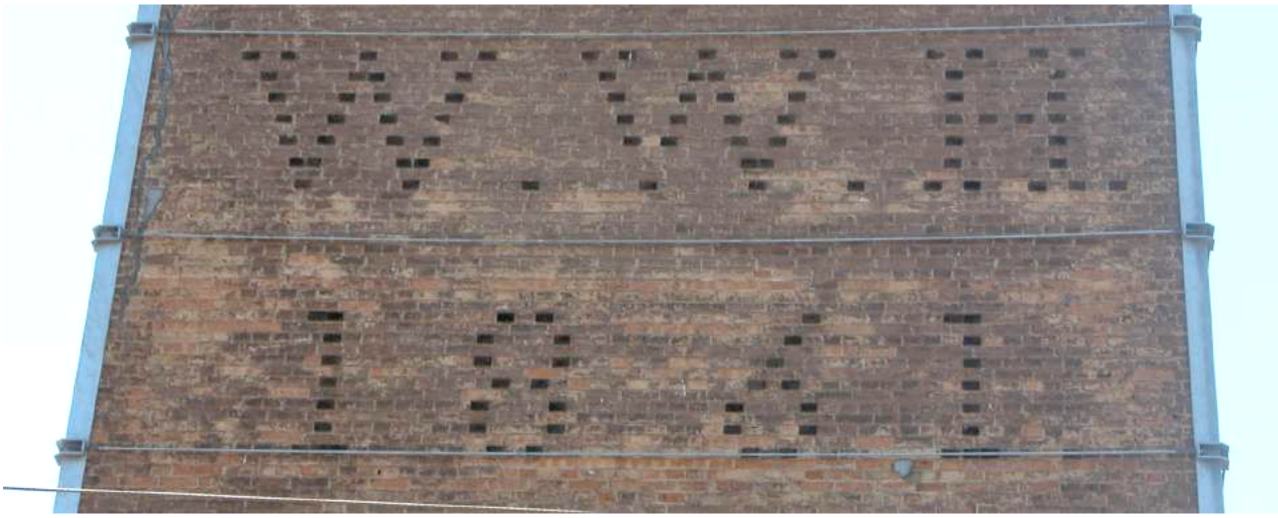


Fig 28 Walter Watson Hughes' initials and the year of construction are picked out
in the brickwork on the east face of the stack

Fig 29 The retaining wall is a dominant element of the site, over six metres high in places, some of its length formed of two walls with internal flues from the furnaces between them

Fig 30 Some elements of the smelters such as the copper store stand outside the project area

Fig 31 The foundations of the smelters store building extend beyond the project area boundary

Fig 32 The furnace area west of Hughes Stack has extensive underground flues

Fig 33 The foundations of the McMurtry sintering pots stand on the upper level (see Fig 19, p. 24)

Fig 34 The paved area on the upper level near the north end of the retaining wall is the charge floor where the blast furnaces standing on the lower level (at left) were fed (see Fig 13, p. 21)

Fig 35 The foundations of the blast furnaces stand below the highest section of retaining wall

Fig 36 Blast furnace foundations, looking south (see Fig 2, p. 9)

Fig 37 The foundations of the converter plant on the lower level (see Fig 21, p. 25)

Fig 38 Power house engine and generator foundations, looking west (see Fig 14, p. 22)

Fig 39 Electrolytic refinery foundations from south-east, slag in background (see Fig 16, p. 23)

Fig 40 Air lift shafts from the coal pulverising plant are among the most conspicuous relics on site

Fig 41 The underground coal conveyor runs from the coal gantry to the pulverising plant

Fig 42 One of the 200m-long coal gantry track foundations, looking north (see Fig. 17, p. 23)

Fig 43 The extensive slag-paved floor of the coke depot

Fig 44 In the north-west of the site are dumps of granulated slag mixed with earth

Fig 45 The older section of the fertiliser factory from north, 1929 power station at right

Fig 46 Some stone masonry elements of the original 1900 fertiliser factory still stand, much altered and in poor condition, view from west

Fig 47 The fertiliser factory office faces Charles Terrace at the entrance to the site

Fig 48 Most of the fertiliser factory's infrastructure dates from recent decades

Fig 49 The Wallaroo smelters site is a museum of bricks from around the world. This small sample all have identifiable brand names. Cowen was the brand of Joseph Cowen & Coy of Blaydon-on-Tyne near Newcastle in the north of England. The Dougall and Gartcraig firebricks were both imported from Scotland, made respectively by James Dougall & Sons Ltd of Bonnybridge and the Gartcraig Coal and Fireclay Coy Ltd of Gartcraig near Glasgow. (Gurcke 1987, Sanderson 1990) The other three are Australian: the Watts firebrick was made by J.S. Watts & Sons at Nairne in the Adelaide Hills, and the Darley firebrick is from the Darley Fire Brick Company of Bacchus Marsh in Victoria, which is still in business today. The Bakewell house brick was made by Bakewell Brothers of Erskineville, NSW

Wallaroo Smelters: Vanished Elements of the Site

The elements of the smelters listed previously are those which are identifiable today. A much greater number of elements, occupying a large proportion of the site, have vanished virtually without trace. Some of these are listed below:

Sulphuric Acid Plant

The acid plant stood on the upper level, in the south-east corner of the site. Its exact site in shown on the 1906 plan, and it appears in many historical photographs, its lead chambers perched one on another forming one of the smelters' most conspicuous structures. Yet there is nothing whatever identifiable on the site today, except the scatter of broken bricks and slag lumps which are found everywhere on the smelters site. The site appears to have been systematically cleared and levelled with earthmoving machinery.

Railway Lines

A glance at the 1906 plan of the smelters shows a maze of railway lines. At that time there were 14 branch lines across the site, on the upper and lower levels. Most of them have vanished, and even their routes are no longer identifiable on the ground Only two abandoned railway tracks within the fertiliser factory building still have rails in situ.

Ore Yard

Ore Conveyors

Ore Crushing Plant

Open Roasters

Gold and Silver Works

Old Refinery (some foundations remain)

Smelters Store (some foundations remain)

Workshops (some foundations remain)

Calcining Kilns

Rotating Calciners

Copper Sulphate Plant

Air Blowers

Brickworks

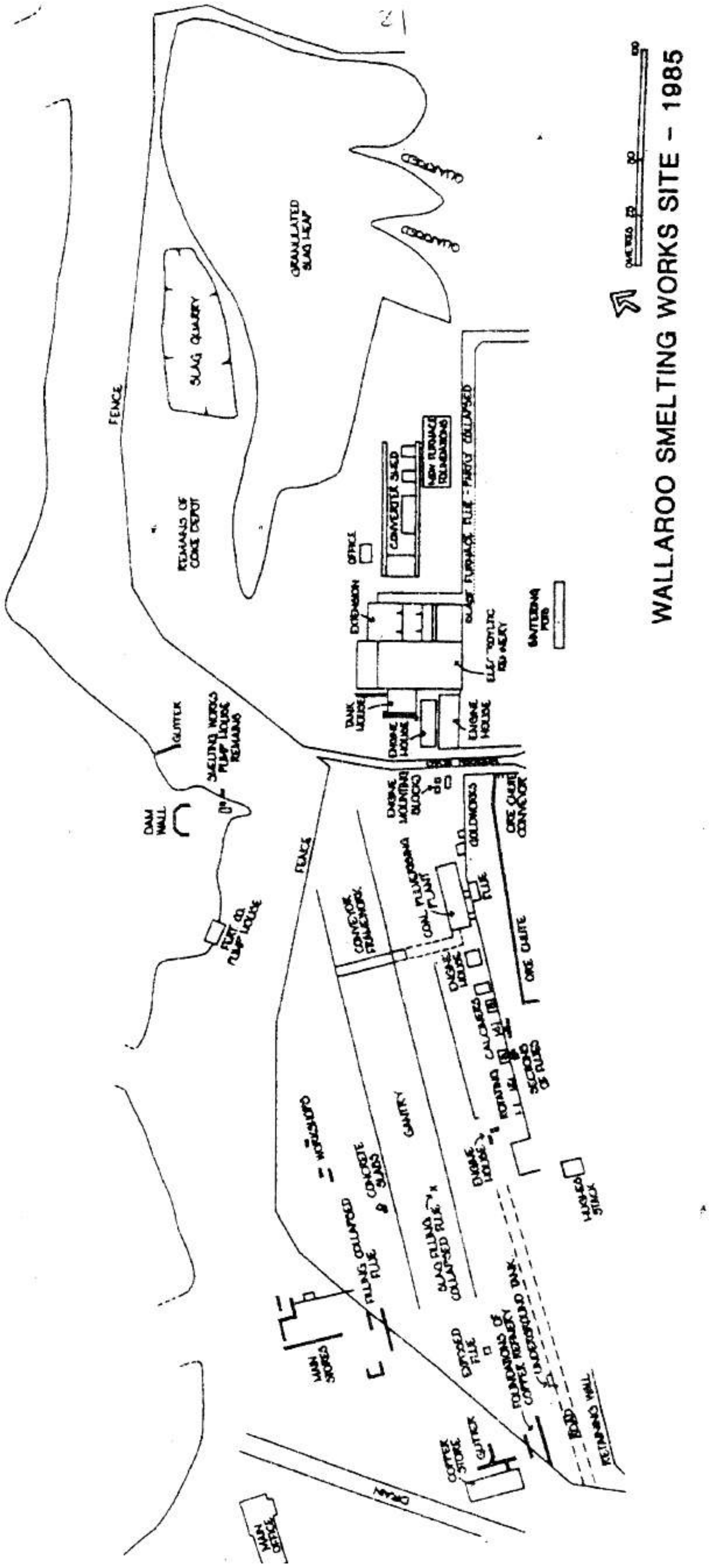
Anode Casting Plant

Pump House

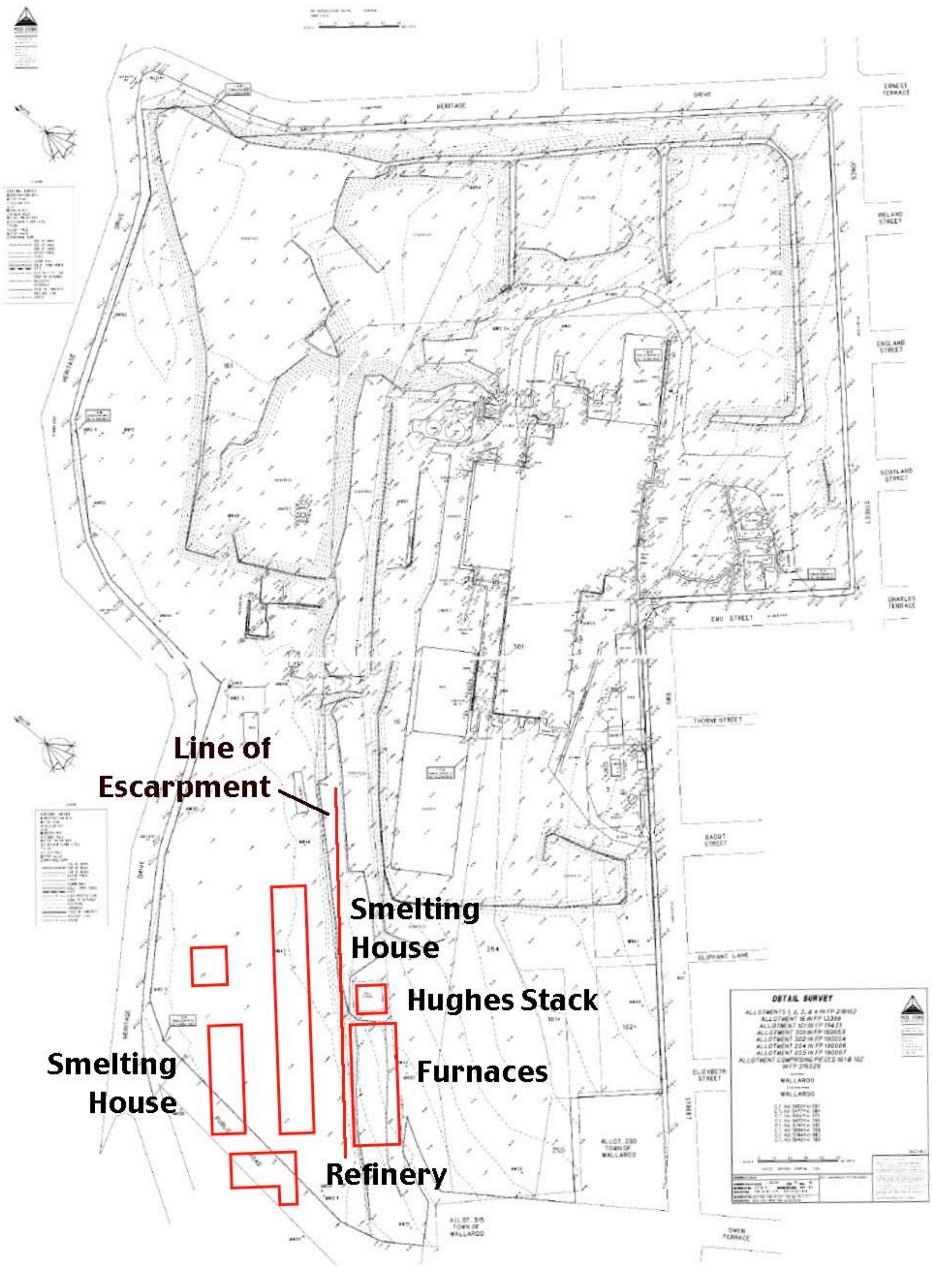
Timber Yard

Coal Depot

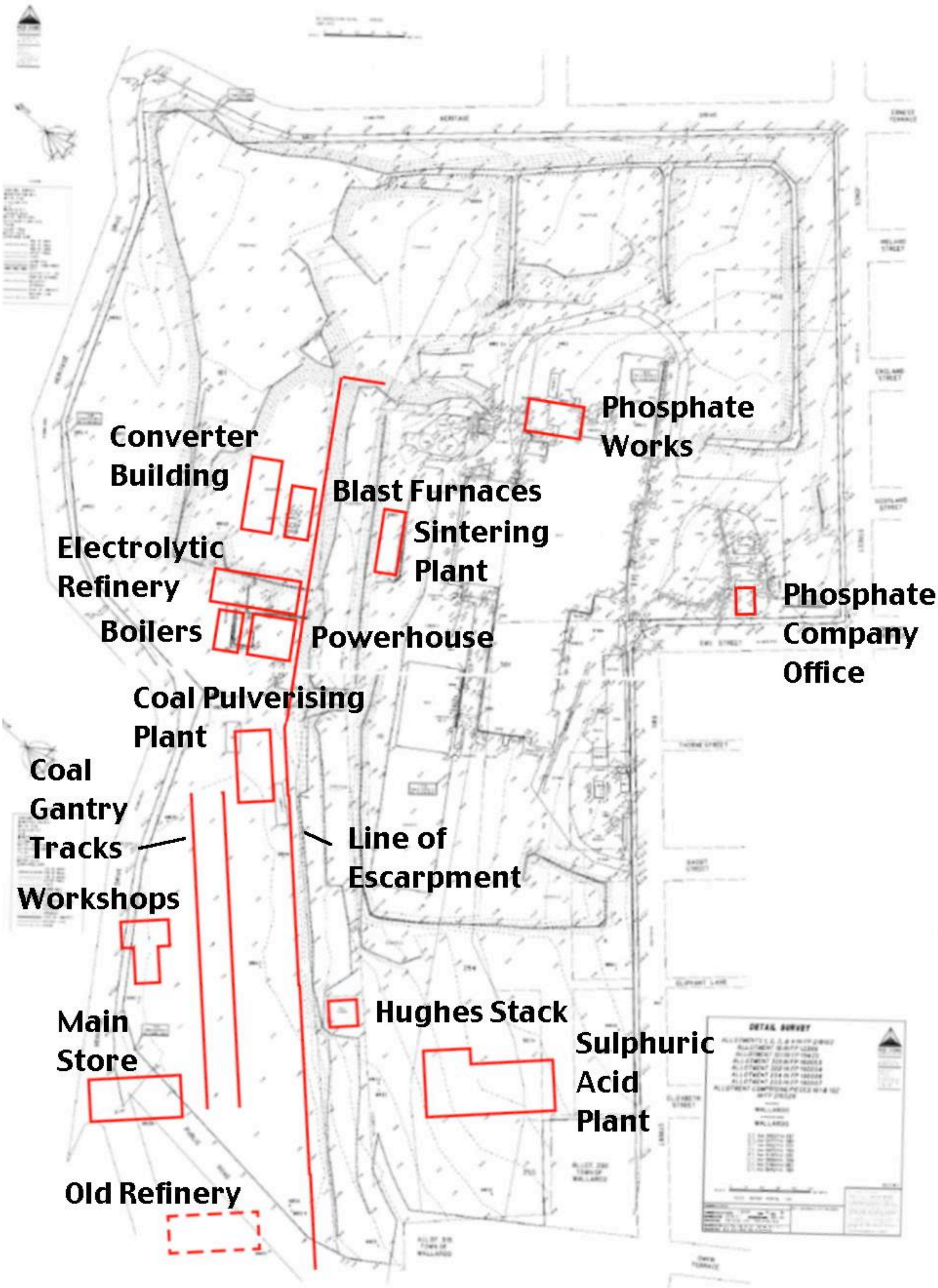
Coke Depot (slag floor remains)



Plan 4 Plan of the smelter remains in 1985 (Bannear 1985)



Plan 5 Plan of the smelters in the 1880s superimposed on the modern survey



Plan 6 Principal historic elements of the smelter superimposed on the modern survey

Wallaroo Smelters: Discussion of Evidence

It is easy to demonstrate that the Wallaroo smelters were of very great historical value to South Australia, and their physical remains constitute one of the largest and most interesting industrial sites in South Australia. This report agrees with the conclusions of the 1985 assessment by the Heritage Branch that the Wallaroo smelters site is of heritage significance and should be entered in the South Australian Heritage Register.

However, that significance does not extend to the entire land parcel on which the smelters site stands. It is very clear that the land parcel investigated in this report contains large areas to which no heritage significance can be attributed.

The land owned by Incitec Pivot can be divided into four sectors, each with a different character. These are:

1 The fertiliser factory building complex about 250m long and 150m wide, which, with its storage sheds, hardstanding areas, fuel tanks and outbuildings, takes up about a quarter of the site.

2 Large areas of the south-east and north-east of the site which are essentially empty space take up about another quarter of the site. They include the empty site of the sulphuric acid works in the south-east. Areas in the north and north-east of the site, although they once belonged to the Wallaroo and Moonta Mining and Smelting Company, do not appear ever to have been developed. They now contain surplus machinery, rubbish deposits, and large earth mounds.

3 The north-west corner of the site is reclaimed seabed underlain by slag, and contains most of the remaining visible surface deposits of granulated slag.

4 The remains of the smelter complex occupy a long narrow space about 600m from north to south and 130m from east to west at the widest point, extending from the southern boundary up the western side of the site. (See Plan 8 on page 59) This area contains the surviving elements described previously: Hughes Stack, the retaining wall, furnace bases and flues, foundations of blast furnaces, sintering plant, converters, powerhouse, electrolytic refinery, coal pulverising plant and coal gantry tracks. Most of these elements are below the retaining wall, extending toward the western boundary of the site. The only significant surviving elements east of the retaining wall are Hughes Stack, the sintering pot bases and charge floor.

Of the entire site, the places of significant heritage value are confined to Sector 4, which contains the smelter ruins. Sector 1, the fertiliser factory complex, is for the most part of no heritage value. It is an empty industrial building, neither very old, historically significant, aesthetically attractive or technologically interesting. The two small stone structures subsumed within the north end of the complex may be part of the original works built in 1900, but if so they are now of very little heritage value. They contain no evidence of the fertiliser manufacturing process, have been altered beyond recognition and are no longer viable buildings. Their condition would make it impossible to retain them if the surrounding complex was demolished.

The one intact and viable building remaining from the fertiliser factory is the office of the Charles Terrace frontage, dating from between 1906 and about 1914. A stone building of domestic scale, it could easily be converted to a new use, and if retained would appropriately represent the fact that a superphosphate fertiliser factory operated at Wallaroo for most of the twentieth century.

Sector 2 contains nothing of heritage value. The slag in Sector 3 is a product of the smelters and intimately related to their operations, but there appears to be no significant quantity of it which is still *in situ*, and there is clear evidence that the deposits have been moved and re-shaped in recent decades. It would be appropriate for a quantity of slag to remain on the smelters site, but it is difficult to attribute heritage value to the existing slag deposits *en masse*.

Essentially, the place of significant heritage value on the smelters site is Sector 4. A boundary has been surveyed defining this place, and most of the recommendations of this report will be concerned with that area.

There are several additional elements of the Wallaroo smelters which are outside the project area covered in this report, as they are on separate land parcels not in Incitec Pivot's ownership.

There are two intact buildings surviving. These are the Smelters Office (c.1880), for many years the Mission to Seamen and now the Seafarers Centre, and the Assay Office (1873), now used as offices and accommodation rooms in a caravan park. Both are located near the foreshore between the smelters site and the jetty.

In addition there are foundation elements of the copper store, old refinery, smelters stores and workshops which extend onto public land to the south and west of the Incitec Pivot land. These have been reduced to minor fragments and no recommendations will be made for them.

Wallaroo Smelters: Assessment of Significance

The following assessment of the heritage significance of the Wallaroo Smelters site is based on the Criteria in the Heritage Places Act 1993. It distinguishes between the heritage significance of the Wallaroo Smelters site proper, and that of the surrounding land contained within the project area.

Heritage Criteria

This assessment of the heritage significance of the place is undertaken using the criteria in Section 16 (1) of the Heritage Places Act 1993, which states that: "A place is of heritage significance if it satisfies one or more of the following criteria". Those criteria did not exist when the property was assessed for the Register of State Heritage Items in 1980 and again in 1985, so no previous assessment of the property has taken them into account. Several of the criteria can be applied to the Wallaroo Smelters site proper, but not to the surrounding land.

> **(a) it demonstrates important aspects of the evolution or pattern of the State's history; or**

The crucial test for the application of this criterion to a place lies not in the general "evolution or pattern of the State's history", but in the words "demonstrates important aspects". That means the place should inform us about some important aspect of our history. The Wallaroo Smelters were certainly the largest smelters in South Australia throughout their life, probably the largest smelters in Australia for much of that time, and it has been repeatedly asserted that for a time in the nineteenth century they were the largest smelters in the world. They were at the heart of the operations of the Wallaroo and Moonta Mining and Smelting Company, the first company in Australia to pay a million pounds in dividends, for decades the largest company in Australia, and a mainstay of the South Australian economy for sixty years. The Wallaroo Smelters site in Sector 4 eloquently demonstrates the role it played in South Australia's history. The surrounding land does not.

> **(b) it has rare, uncommon or endangered qualities that are of cultural significance; or**

There are a number of other historic copper smelting sites in South Australia (Burra, Kapunda, Callington, Kanmantoo, Charlton Run, Blinman, Yudnamutana, The Peake), but the sheer physical scale of the Wallaroo Smelters site, together with its economic importance, distinguish it as having rare and uncommon qualities.

The McMurtry sintering pot bases at Wallaroo are certainly rare, and probably unique.

> **(c) it may yield information that will contribute to an understanding of the State's history, including its natural history; or**

The application of this criterion usually refers to the potential of a site for archaeological investigation, whether by excavation or otherwise. The Wallaroo Smelters site contains a number of building foundations and archaeological deposits - particularly the large area of furnace flues - which is likely to yield information about nineteenth century copper smelting technology. The surroundings outside Sector 4 have been altered by eighty years of comprehensive demolition, scavenging and earthmoving, and their potential for archaeological research is much diminished.

(d) it is an outstanding representative of a particular class of places of cultural significance; or

The Wallaroo Smelters site is the outstanding, almost unique, example within South Australia of metallurgical expertise. World-renowned, large, prestigious, at the forefront of technology, it dominated the base metal industry in Australia for decades. The other South Australian smelter which compares with it is Port Pirie, established in 1889 to treat ore from Broken Hill, greatly expanded in 1915 to become one of the world's greatest smelters, and still in production today, thanks to more productive mines and greater success than Wallaroo in diversifying its client base. When Wallaroo closed, Port Pirie essentially took over its role in South Australian metallurgical processing.

(e) it demonstrates a high degree of creative, aesthetic or technical accomplishment or is an outstanding representative of particular construction techniques or design characteristics; or

A number of metallurgical developments within the Wallaroo Smelters site demonstrate a high degree of technical accomplishment. It was among the first smelters in Australia to transform its operations by adopting the new technologies of waterjacket blast furnaces, converters and electrolytic refining, and the evidence of these operations can still clearly be seen at the site. The McMurtry-Rogers sintering process was developed at Wallaroo, a technological achievement specific to this site, and the concrete foundations of the sintering pots still stand.

(f) it has strong cultural or spiritual associations for the community or a group within it; or

The Wallaroo Smelters site has particular significance for the South Australian Welsh community, whose ancestors made up most of the skilled workforce in the nineteenth century. Like Burra, Wallaroo had a significant Welsh immigrant population which can still be recognised in the community. This may fall short of a strong association.

(g) it has a special association with the life or work of a person or organisation or an event of historical importance.

The Wallaroo Smelters site has special associations with a number of persons and organisations of historical importance to South Australia, notably the Wallaroo and Moonta Mining and Smelting Company, and Walter Watson Hughes, Edward Stirling, Thomas Elder, Robert Barr-Smith, Robert Stuckey, George Waterhouse and Anthony Forster, among other notable individuals, who were directors of the company.

These associations were by no means incidental. The success of the company, achieved through the output of the Wallaroo Smelters, was the principal source of earnings for many of these people. That success can be seen today on North Terrace, where the statues of Hughes and Elder, the principal benefactors of the University of Adelaide, are both commemorated by bronze statues on its lawns. Their generosity was funded by Wallaroo copper.

Sir Thomas Elder in particular left an impressive legacy, including his business enterprises, Elder Smith and Company and the Beltana Pastoral Company. He funded outback exploration expeditions and throughout his life engaged in philanthropy, leaving such iconic public monuments as the Elder Park rotunda. His posthumous Elder Bequest enabled Elder Hall and a School of Anatomy to be built at the University of Adelaide, as well as the Art Gallery of South Australia alongside, and funded much of its impressive collection. The Wallaroo Smelters made much of this possible.

On another plane, the technological achievements of the Wallaroo Smelters were made possible by the work of the shrewd and competent father-and-son General Managers Henry Richard and Henry Lipson Hancock, as well as such distinguished engineers and metallurgists as smelters managers Thomas Cloud and George McMurtry. Their associations with the Wallaroo Smelters are both special and important.

In summary, the Wallaroo Smelters site meets nearly all the criteria for entry in the South Australian Heritage Register. None of these criteria can be applied to the surrounding land, which does not demonstrate any such associations.

Appended to this report is an in-house assessment of the Wallaroo Smelters site's heritage value, undertaken by the Heritage Branch in 2002. (See page 65)

Wallaroo Smelters: Recommendations

1 The Wallaroo Smelters Site should be re-defined with a clear boundary, distinguishing it from the remainder of the Incitec Pivot land, which contains nothing of significance.

2 This should be recognised by excising the Wallaroo Smelters Site from the remainder of the Incitec Pivot land as a new allotment on a new certificate of title. The proposed boundary of this allotment is shown on Plans 7 & 8, pages 58 and 59.

3 This new allotment should be entered in the South Australian Heritage Register and declared a place of archaeological significance.

4 A permanent fence with appropriate vehicle and pedestrian gates should be erected around the new allotment to define it physically.

5 The District Council of the Copper Coast, the Heritage Branch and the Coast Protection Board should be consulted about these proposals. (This will happen in any case as part of the development approval process.)

6 Ownership of the new heritage allotment should be transferred to the District Council of the Copper Coast.

7 The remainder of the Incitec Pivot land, including the fertiliser factory buildings, should be removed from the South Australian Heritage Register, with the exception of the former fertiliser company office on Charles Terrace.

8 The former fertiliser company office on Charles Terrace should be entered in the South Australian Heritage Register as a separate place. This should be done after it has been surveyed onto a new allotment as part of subdivision of the land.

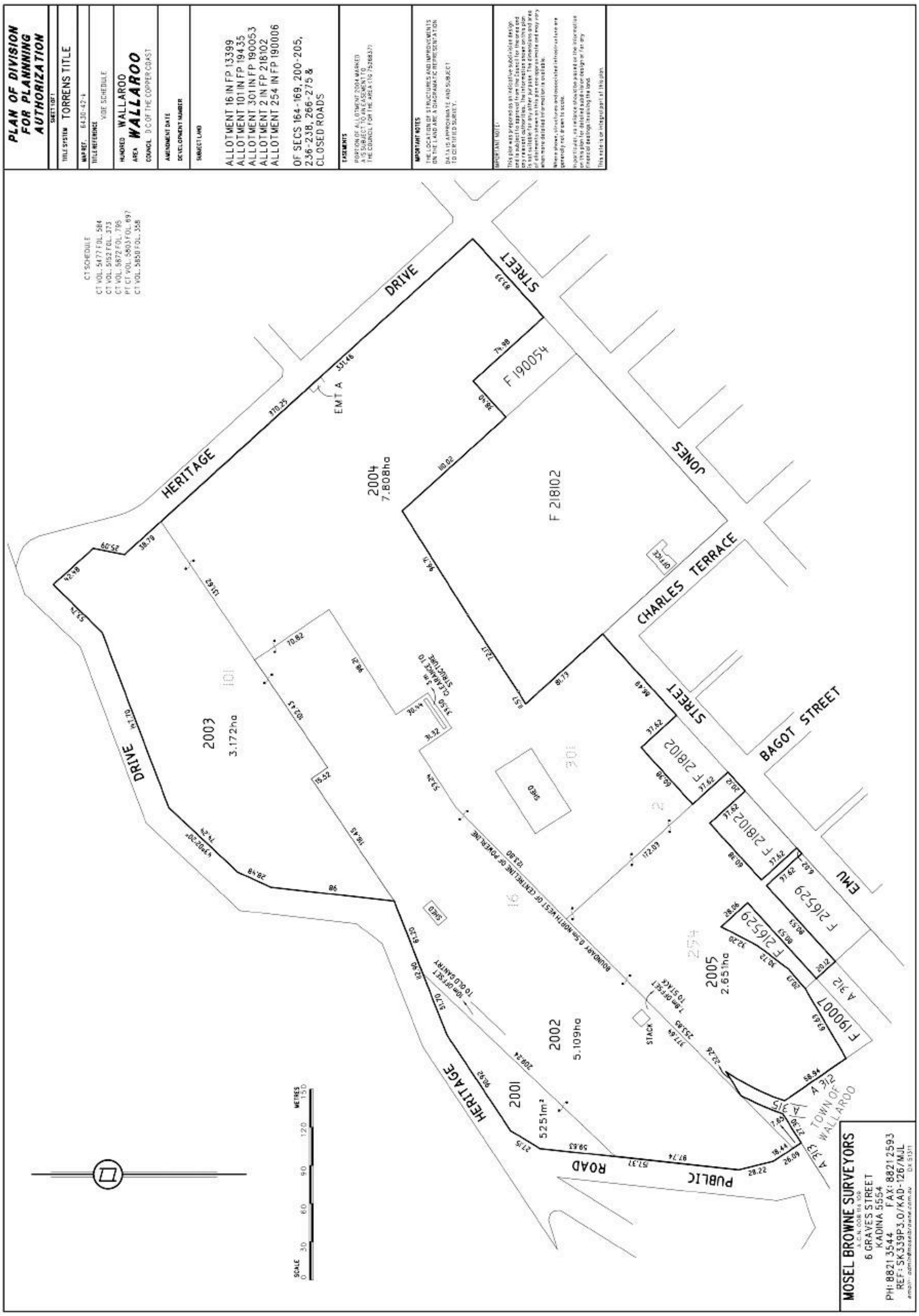
9 Public access to the new heritage allotment should be encouraged.

10 To facilitate public access, minor site works and rubbish clearance need to be done for safety and aesthetic reasons.

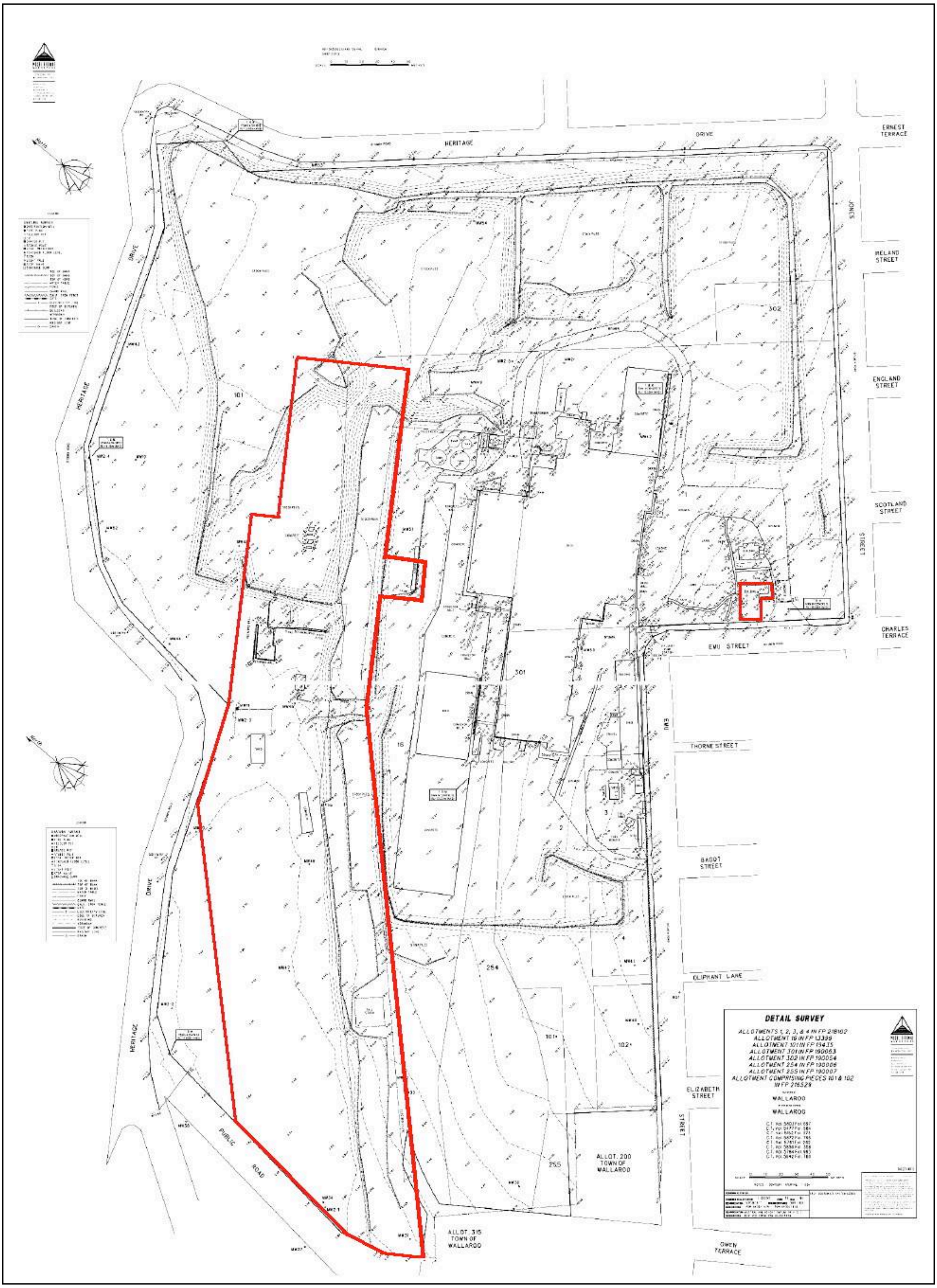
11 A walking trail through the smelters site with interpretation signage should be established on the new heritage allotment.

12 The most appropriate public entry point to the walking trail is the former railway gates off Jetty Road at the south end of the site, close to the Wallaroo Heritage and Nautical Museum.

13 A quantity of granulated slag should be retained on the new heritage allotment.



Plan 7 Plan of proposed heritage boundary at Wallaroo Smelters site (Mosel Browne Surveyors)



Plan 8 Proposed heritage boundary superimposed on survey plan of Wallaroo Smelters site

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Appendix 1: Heritage Branch Assessment of Significance 2002

WALLAROO SMELTER SITE

Statement of Heritage Value

Heritage SA

The Wallaroo smelter and refinery was established in 1861 to process material from the nearby Wallaroo and Moonta copper mines. It remained in production until 1926 and is associated with W W Hughes and other directors of the Moonta and Wallaroo mining companies. The site is significant as the remains of South Australia's largest industrial complex for much of the period 1861-1926, and for a time one of the great smelters of the world. It is a rare site and is of great technological and archaeological significance (HSA, 1/2000).

Archaeological survey

The cultural significance is dependent on the entirety of the site rather than any separate section. The site documents some 60 years of constant change which is important, rather than individual remains.

Site

Development of site usage in 3 phases:

1	1861-1889	Welsh method of copper smelting
2	1889-1907	New technology and diversification of interest
3	1910-1923	Bessemerizing method of copper smelting

The whole of the site is important rather than any particular section. In many cases buildings were demolished or converted to new uses as each phase evolved. As such the site cannot give a complete 'snapshot' of each individual phase, but enough remains of each to be able to trace the evolution and development of the site. No one phase was more important than the other.

The southern section contains evidence of all 3 phases, the northern section, phases 2 and 3. Sections are important for different reasons:

southern	oldest remains, including Hughes stack
northern	provides the physical evidence by which one can trace how the old Welsh method of copper smelting evolved into the Bessemerizing method of phase 3

The site is archaeologically important because physical evidence of how the smelting operations developed has survived. These features have not been built over, and so despite damage to some of the remains, the site largely retains its integrity.

Summary

Historically it is the whole site that is important – depicting the evolution and development of the State's largest copper smelting complex. Each phase of this evolution was involved with the processing of copper smelting (and its by products) and all elements associated with that processing are important. The significance of a structure is enhanced by the presence of other elements associated with the function of that structure.

Physically, the majority of structures are in similar condition (ie footings, foundations only). Many of the structures were used in a least two of the phases of development, others were replaced. No preference (in terms of heritage value) can be given to one structure over another in terms of the quality of its remains. The exception is the Hughes Stack which is the most complete structure within the smelter site.

NORTHERN SECTION

Item	Phase 1	Phase 2	Phase 3
McMurtry Sintering Converters		late	X
Blast furnace flue		late	X
Power plant		late	X
Electrolytic refinery		late	X
Electrolytic refinery extension		late	X
Blast furnace flue		late	X
Bessemerizing plant/Converter shed			X
New furnace			late
Granulated slag heap			X

SOUTHERN SECTION

Item	Phase 1	Phase 2	Phase 3
Ore chute/Conveyer			late
Gold works/Smelting & Calcining plant		mid	
Copper works rotating calciners		X	
Coal pulverising plant			late
Coal depot/Gantry tracks			X
Smelting works pump house & dam			X
Copper store		late	X
Flue system		X	
Main workshops		X	X
Main stores		X	X
Retaining wall		X	X
Hughes stack	X	X	
Reclaiming upper level with molten slag		late	
Main office	late	X	X

Appendix 2: Project Brief

BRIEF FOR A HERITAGE CONSERVATION STUDY OF THE WALLAROO SMELTER REMAINS

1. Background

The Wallaroo smelters operated on a coastal site in the town of Wallaroo from 1861 until 1923. The smelter site, which consists of a large area of fragmentary ruins, slag and other waste, and a later fertiliser factory now disused, has been entered in the South Australian Heritage Register. A modern marina and residential complex has been developed adjacent to the smelter site in recent years. Incitec Pivot Ltd, owners of the former smelter site, are investigating the feasibility of redeveloping the land to realise its potential for residential and recreational use.

It is necessary to define the development constraints on the site, which include the heritage significance of the smelter remains, requirements of the Development Plan, contamination issues, and disposal of groundwater from the land, so that these can be reconciled with the reasonable expectations of the owner to create more certainty for planning the redevelopment. The study outlined in this brief deals with the heritage issues, which will be integrated with the other constraints into an overall site management plan.

2. Objectives

(a) to review the written records of the site, and the remaining fabric and artefactual record of the of the site as a whole in order to improve current statements of significance and provide understanding of the above- and below-ground remains and their historic value to the site as a whole,

(b) to provide the heritage elements of an overall Conservation Management Plan (CMP) mapping and giving a detailed description of the heritage values of the site, articulating those values in a statement of significance and setting out policies for best management of that significance in accordance with the principles of the Burra Charter.

3. Requirements

3.1 Overview History

Carry out historical research establishing the principal events in the development of the smelter site 1861-1923 and write a succinct overview history which will provide the basis for understanding the function and significance of the physical remains on the site. This overview will also be used in any future site interpretation material.

This overview history should take into account the historical background research already provided by the report:

Bannear, David, Archaeological Survey of the Wallaroo Copper Smelters, unpublished report to South Australian Department of Environment and Planning, 1985.

3.2 Fieldwork

Carry out a thorough physical inspection of the smelter site to identify, locate and describe its recognisable historic elements.

All field observations should be recorded by means of written notes, drawn plans and photographs, regardless of the recommendations that may finally arise.

3.3 Assessment of Significance

Based on the historical overview and field observations, draw up an assessment of the relative heritage significance of the remaining elements of the smelter site. The assessment of significance should be based on the criteria in Section 16(1) of the Heritage Places Act 1993 for the entry of places in the South Australian Heritage Register.

The assessment should assign levels or categories of heritage significance to the elements of the smelter site, using such terms as for example exceptional, considerable, some, little, none or negative, keeping in mind that this process is intended to assist the identification of areas of priority for redevelopment or conservation.

These categories of heritage significance should be clearly identified by means of a site map or maps showing their relative importance to the heritage value of the site as a whole.

3.4 Policy Recommendations

Draw up heritage management policies for the remaining historic elements of the smelter site, reflecting the distinct levels of heritage significance which have been identified. These policies should incorporate a strategy for public site access and interpretation. The scope of the policies should range in priority, focusing management resources on elements with the highest levels of significance, and ranging down to identify areas of little or no significance, where no management recommendations are necessary.

These policies should divide the site into clearly defined areas for management purposes. The boundaries of policy areas should be clearly defined by means of a map or maps of the smelter site. The assessment of significance may lead to recommendations for a changed definition of the area of land entered in the South Australian Heritage Register.

3.5 Management Recommendations

Express the overall policies in the form of recommendations for the conservation management of those elements of the site which have been identified as having significant heritage value. These recommendations might include such options as (a) conservation work to extend the life of historic fabric, (b) remediation to reduce safety hazards, (c) works to improve public access and (d) interpretation for visitors.

4. Presentation

The Consultant will first submit a draft report of the Heritage Conservation Study to Incitec Pivot Ltd and the Heritage Branch for discussion and amendment, at a time agreed in the survey timetable.

The Consultant is to present the master copy of the final report of the study in A4 format ready for binding, as well as a copy of the report on computer disks in a format which can be readily be used by Incitec Pivot Ltd and the Heritage Branch.

The final report of the heritage survey is to contain:

(a) an overview of the history of the smelters, providing a context for the policies and recommendations of the final report;

(b) a detailed description of the surviving historic elements of the site;

(c) an assessment of the relative heritage value of the surviving historic elements of the site;

(d) policy recommendations for the site, reflecting this range of heritage values;

(e) management recommendations with sufficient detail for the successful implementation of these policies;

(f) maps showing the location of all the places and areas in (b) - (e) above;

(g) a bibliography of documentary and other sources consulted during the historical research for the overview history.

5. Timetable

The survey will commence on

The survey will be completed by

The consultant will at the commencement of the heritage survey prepare a timetable for the stages of the survey, to be agreed to by the client and will advise the client of any proposed changes to that timetable.