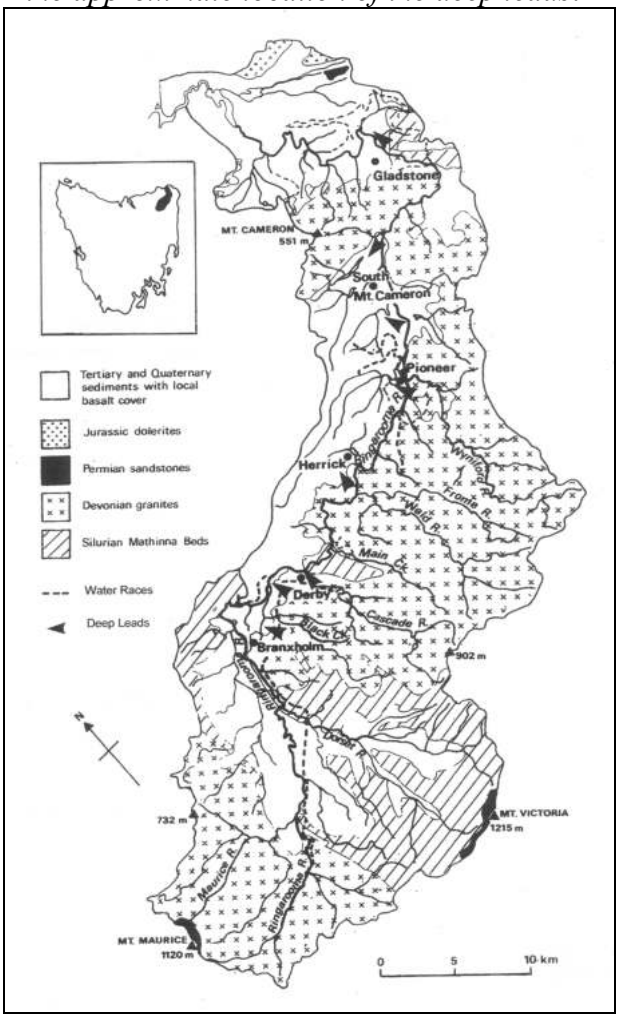
Tailings disposal at the Arba Mine: a legislative nightmare

By KEITH PRESTON

The Ringarooma basin in northeast Tasmania formed the state's premier alluvial tin mining area for a century following the first discovery in 1875. With a catchment area of approximately 955km^2, the basin extends for 60km (N-S direction) by 10-22km (E-W), its tributaries draining upland areas along the southern and eastern watershed boundaries that include Mt Maurice (1120m), Mt Victoria (1215m), Rattler Hill (902m) and the Blue Tier massif (Fig. 1).[1] During the Tertiary era, a land-locked lacustrine basin formed to the south of Mt Cameron (551m). Erosion of the mineralised cap of the granite batholiths that formed the upland areas led to extensive alluvial tin deposits accumulating in palaeochannels. These were buried beneath further sediments that were in places covered by Tertiary basalt flows. Renewed erosion by the re-established Ringarooma River gradually exposed the deep leads along the riverbed that were worked largely by hydraulic sluicing.[2]

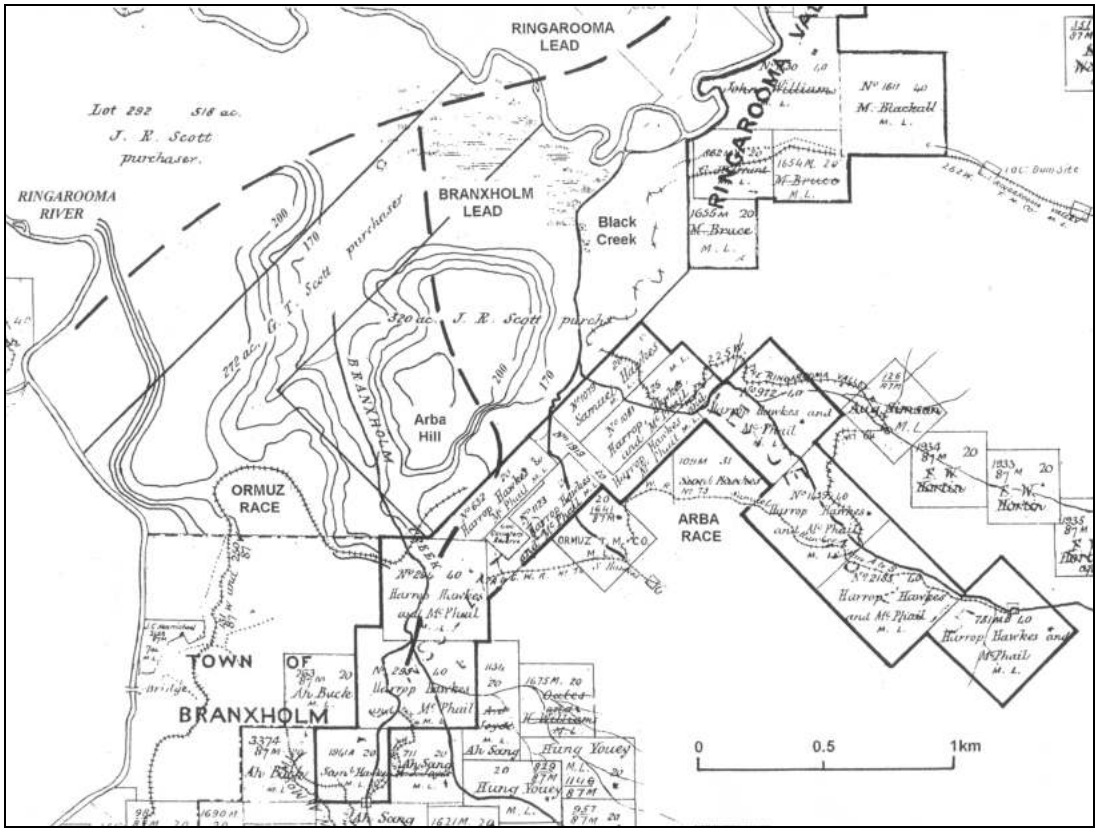
Figure 1: *Geology of the Ringarooma Basin showing the approximate location of the deep leads*.



Source: A.D. Knighton, 'Tin Mining and Sediment Supply to the Ringarooma River, Tasmania, 1875-1979', *Australian Geographical Studies*, vol. 25, no. 1, April 1987, p. 84.

Mining in the vicinity of Branxholm commenced in mid-1875, following the initial discovery of tin by William Pearce on Branxholm Creek at Ruby Flat, about 3km southeast of the township, and a first consignment of 3.05t tin oxide was sold to the Mount Bischoff Co. smelter at Launceston in January 1876.[3] Operators of the Golden Age claim at Ruby Flat, Launceston grocers Alexander McPhail and George Weymouth[4] shipped the first tin consignment from the newly-established port of Bridport the following August, before commencing a partnership with banker Edward D. Harrop and mining investor George Babington to form the Arba Association.[5] Output for the first quarter of 1877 amounted to 50.8t, enabling the syndicate members to take a £50 dividend in March and another of £100 six weeks later – a promising beginning.[6] Shallow alluvial deposits along Branxholm Creek within the leases held by McPhail and Weymouth (Leases 294 & 295 on Fig. 2) were worked initially on tribute by ground sluicing.[7] An agreement to lease an 8ha portion of the privately owned Branxholm Estate adjoining the northern boundary of Lease 294 referred to as the Celt workings, commenced in March.[8]

Figure 2: *Lease holdings of the Arba TM Co. along Branxholm & Black Creeks, the Branxholm Estate landholdings to the northwest and the water supply races. Location of the Branxholm Lead added from Mineral Resources Tasmania Report 63-0364, 1964. Contours (at 10m intervals) outlining the Arba Hill added from TASMAP 1:25,000 Derby Sheet, 2011.*



Source: Mineral Resources Tasmania, Mineral Chart 149b, November 1885 - May 1891.

Samuel (Sam) Hawkes engaged as mine manager early in 1878, was in time to witness flood damage from winter rains to dams and water races that were 'swept clean away' and the Celt workings being submerged, highlighting the considerable risks associated with mining close to a major river.[9] A water race was under construction from higher ground along Black Creek (water rights WR 73 & 74 on Fig. 2) in September 1881 to meet a requirement for additional water.[10] The

following month, one of the first disputes before newly-appointed Mines Commissioner for the North-East District, was that of Sam Hawkes, who was seeking to prevent the discharge of tailings from neighbouring (upslope) leases into Branxholm Creek – tailings disposal had become an issue less than six years after mining commenced.[11]

Synthesis of the tailings issue

Government Geologist Gustav Thureau undertook the first geological mapping of the upper Ringarooma valley at the end of 1883 but his opinion cast doubt on the extent of the Arba deposits:

> the 'main channel' or 'lead' from the Arba Company's mine ... has been so much denuded, where it is traversed or crossed by the present river, so as to render it somewhat doubtful for any of the original deposits to remain except at great depth.[12]

Thureau's mapping showed the Branxholm Lead swinging to the northeast from Lease 294 below the elevated *Arba Hill,* which formed part of the Branxholm Estate. This land was accumulated by Former parliamentarian and colonial secretary James Reid Scott, together with his cousin George, accumulated this land and in June 1860, began to form a pastoral estate of 450ha within a pronounced meander of the Ringarooma River (Fig. 2).[13] All of the tailings from alluvial workings along Branxholm Creek and Black Creek to the northeast were conveyed through the Branxholm Estate before discharging into the Ringarooma River.

Following completion of Arba's Celt workings, Scott's trustees (widow Elizabeth, cousin George and neighbouring landowner Thomas M. Evans) commenced legal action in April 1884 against the Arba Association, seeking damages for accumulated 'sludge, tailings and silt'. As there was no provision within the *Mineral Lands Act 1884* for tailings disposal on private land (only on crown land), the Arba Association, which now included Sam Hawkes and legal secretary Torquil H. Urquhart, were forced to negotiate.[14] The resulting agreement included onerous financial conditions – the Association to pay an initial £200 damages together with an annual £100 payment in two instalments, commencing in April 1885. In return, the Association had the right to 'deposit sludge, tailings & silt' for seven years, also to cut a drain not exceeding 1.83m in width through the Branxholm Estate to the Ringarooma River. Mines Commissioner Bernard Shaw was empowered to arbitrate in any dispute.[15]

A different approach was adopted in Victoria, when *An Act to provide for Mining for Gold and Silver on Private Property* (48 Vict. No. 796) was passed in November 1884, after numerous attempts over a 26-year period. This established procedures for the award of leases on private property, and included similar provisions for compensation as those applying to crown lands.[16] Further measures for mining on private property were drafted for the *Mines Act 1890* (54 Vict. No. 1120) which for the first time included all minerals.[17]

Mining below river level 1882-86

Preparations for mining below the level of the tailrace which discharged into Branxholm Creek were underway in August 1882 when the Chinese tributors were replaced by 'European wages-men'. Steam-powered machinery was installed to haul the washdirt up an inclined tramway, the one-ton capacity trucks emptying into sluice boxes for treatment.[18] The adoption of steam power provided a measure of Hawkes's confidence in the continuation of rich tin deposits with depth, and

also reflected on the limited water supply available from Black Creek that was required for sluicing. This is emphasized by a dispute with the neighbouring Ibis claim when Hawkes was found guilty by the Court of Mines of diverting water into the Arba headrace in June 1883 and September 1884, restraining orders being issued on both occasions.[19]

Development costs amounted to £14,800 during 1883-84, Hawkes boasting that 'since he had been connected with that mine [Arba] not one penny of subscribed capital had been spent on it'.[20] By August 1886 the method of working the washdirt had been refined to include a 3.65m long trommel**,** Sam Hawkes claiming that 2,540t a week could be treated at a cost of 7d per ton:

> washdirt is cut away from the tip by a strong head of water which carries the material down a shoot of about 16ft. in length … into a large revolving cylinder perforated with 3 8th and 2 8th holes charged with jets of water; the material is perfectly washed in this process … passes through the perforations to the sluice boxes.[21]

The following month all production was halted by flooding when the 30.5m high working face was 'completely submerged'.[22]

Mining Operations Act (1887) implemented

Sam Hawkes's experience with the inadequacies of the mining legislation appears to have determined the timing (January 1885) of his nomination for the lower house seat of Ringarooma. He was duly elected in July 1886, and two months later was reported to have 'launched out in the direction of assisting mining by moving for a select committee to inquire into and report upon the mining laws of the colony'.[23] The resulting *Mining Operations Act* (51 Vict. No. 2) that passed the Senate in August 1887 at the third reading, was framed to address tailings disposal. A leaseholder could give notice to a private landholder of an intention to acquire up to 12ha as a tailings easement, together with a right to construct a tailrace or sludge channel. A torrent of applications for tailings leases on the Branxholm Estate followed, it being noted that applications from leaseholders of claims along the Branxholm Creek above the Arba 'turned out to be also shareholders [syndicate members] in the Arba Company; but coincidences of this kind do occur in life'.[24] Another bill was hastily drafted and the *Commissioners' Powers Act* (51 Vict. No. 10) enacted on 20th December, making provision for the award of tailings leases (and for dispute resolution) to be overseen by the Commissioners of Mines. This delay had significant repercussions for the Scott vs Arba dispute.

All now appeared clear for the Arba to pursue deeper mining but Scott's trustees had not been idle since Hawkes's election. In February 1887 an agreement was finalised for prospecting on the Branxholm Estate in the area previously worked by the Arba Association (the Celt workings). At the end of March an exploratory adit was being driven in a southerly direction from the Ringarooma River to test the deep lead deposits, and five months later £600-£700 was allocated for further prospecting. Negotiations between the trustees and the Arba Association broke down at this time, the trustees commencing legal action with an hearing in the Supreme Court scheduled for the 7th September[25] but thee passage of the *Mining Operation Act* through the Senate on the 31st August came too late to prevent the dispute escalating.

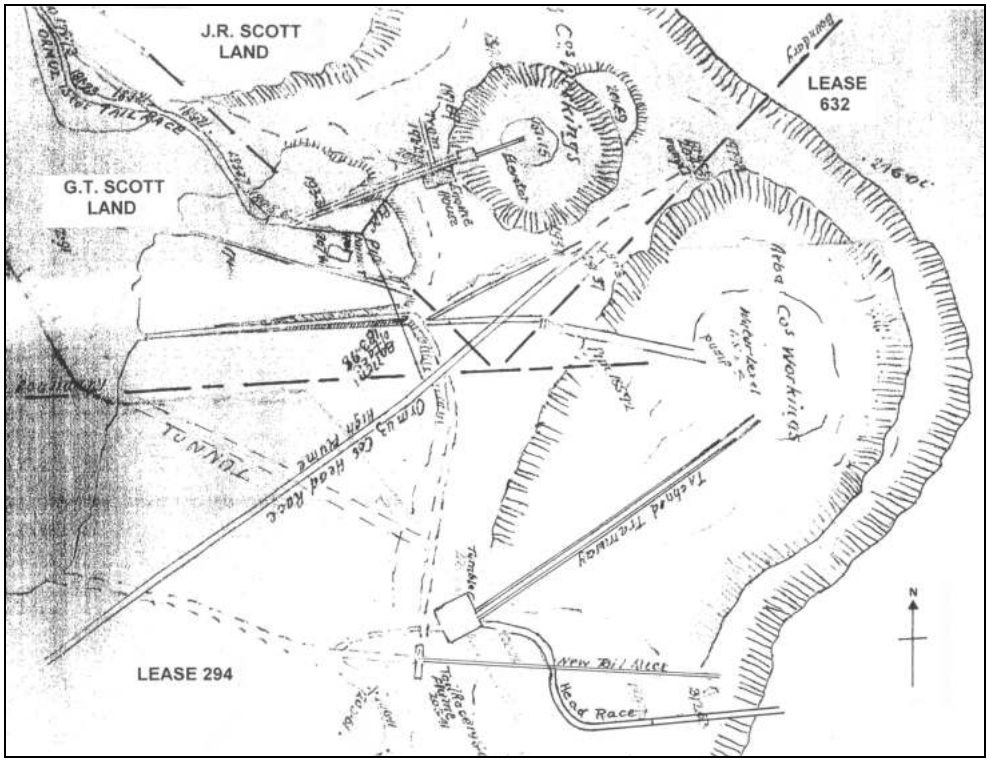
At the Supreme Court hearing, Scott's trustees were represented by the Solicitor-General – a measure of the leverage that the Scott family retained in the newly-elected ministry of Philip O. Fysh.[26] A procession of mine managers supported Sam Hawkes's assertion that some five times the daily throughput of the Arba mine (203t) was worked by hydraulic sluicing on claims upslope of

the Arba. Despite this, all blame was attributed to the Arba, and an injunction issued restraining further tailings discharge within the Branxholm Estate. The company was fined £450 for damages and ordered to pay legal costs for the three-day hearing.[27] The problem now passed to the Court of Mines, where at a hearing six months later before Commissioner O'Reilly, more mine managers testified that tailings were being conveyed by Branxholm Creek from the 'outer workings' through the Arba leases. O'Reilly was unimpressed with the 'paucity of reliable evidence', and the hearing was adjourned and no report of a resumption has been found – clearly the new legislation was not fulfilling its intended purpose.[28]

A competitor on the doorstep – 1888

By March 1888, prospecting on the Branxholm Estate had convinced Branxholm storekeeper Edward Allen of the tin potential, so he made an application was made for a 25 SH [sluice-head][29] water right from the Dorset River. A 11.8km long headrace extending southward from the lease was required for which tenders were called the following month when a prospectus for the Ormuz TM Co. [Tin Mine Company] was issued. This sought to raise £9,375 in a public float of 25,000 shares, of which £4,000 was to be allocated for the initial working capital.[30] Melbourne-based consulting mining engineer Robert Dunlop Thompson was engaged, recommending construction of a well-engineered headrace from the Dorset River at an estimated cost of £2,500.[31] Mine manager George Webb directed construction of the 'finest race in the island' comprising 10km of ditch cutting, a 159m long tunnel (on the Branxholm Estate) and 1,610m of fluming up to 15m in height. It was completed in May 1889 at a cost of almost £5,000, much to the consternation of shareholders, when Chinese tributer Yet Foos was awarded a two-year contract at a royalty of £21 per ton.[32]

Figure 3: *Arba & Ormuz Co.'s workings showing water supply races, Arba drainage tunnel and haulage incline, and Ormuz elevator.*



Source: Tasmanian Archive & Heritage Office, AB948/1/41, undated but probably late 1892.

Changes were also underway at the Arba, with the formation of the limited liability Arba TM Co. in June 1888. No public float was involved, all 48,000 (£1) shares being held by the remaining syndicate members: Harrop (16,000), Babington, Hawkes, Urquhart and legal secretary Melville Stackhouse (8,000 each).[33] It was reported that the shares were to be paid up to 15 shillings, which would have required a substantial financial commitment from the syndicate members. This should have been within their financial means, as an estimated revenue of almost £66,000 was generated from some 1,400t tin oxide produced between 1877-88.[34] Additional finance was required to construct a new tailrace to Black Creek to the northeast as the new Ormuz workings cut the old tailrace (see Fig. 3), to undertake exploratory drilling to locate the lead and to address mine pumping as groundwater seepage was preventing mining below a depth of about 25m. Mine manager William Anderson supervised the installation of a Cornish drawlift pump driven by a 7.0m waterwheel, which was operational by July.[35]

Groundwater inflows and another dispute - 1889

A month after the Ormuz tributers commenced sluicing, no doubt using copious quantities of water from their expensive supply race, the Arba manager observed groundwater seepage in the northern pit wall. This led to slumping of the poorly consolidated sediments along the steep batter face, and an accumulation of sludge in the base of the pit, thereby hindering mining.[36] In response to complaints, towards the end of August, the Ormuz manager commenced building a drainage shaft for the installation of a Cornish drawlift pump. A waterwheel had been erected by the beginning of October, it being noted, the 'bob pit is completed and the bob made … busy making sweep rod and fluming to convey water from the wheel'.[37] Completion of the pump a month later merely slowed the rising water level in the Arba pit, leading to a suspension of all work in October until the dispute was resolved.[38]

An application for an injunction against the Ormuz Co. was lodged in the Supreme Court on 10th August but a three-month delay elapsed before the case was heard.[39] By mid-December when the hearing commenced, the water level in the Arba pit had risen 6.1m and £1,500 in damages was sought. Conflicting claims were made as to the cause of the water inflows but the most reliable evidence was probably that of former mine manager William J. Shepperd, who considered groundwater seepage the principle cause, exacerbated by stormwater inflows into the pits.[40] The ruling in March instructed both companies to undertake co-ordinated drainage measures to combat groundwater inflows: the Ormuz by means of a new shaft for pumping located close the lease boundary (see Fig. 3), the Arba by constructing a 423m long drainage adit, all maintenance costs to be shared. Ex-Commissioner of Mines Bernard Shaw was called upon to make a decision on damages – none were awarded, and the ruling was ratified two months later by the Supreme Court.[41]

More legislation - November 1889

While the Arba vs Ormuz dispute was proceeding further legislation was drafted, six weeks being required for *The Land for Mining Purposes Act* (53 Vict. No. 24) to pass through Parliament. It was enacted on 9th November 1889, empowering the Minister of Lands & Works to purchase land for 'Public Tailings Areas & Sludge Channels, and for the purpose of diverting water'. Scott's trustees were advised that sections of the Branxholm Estate were to be purchased five months later.[42] This

could not proceed until the Senate approved an allocation of £1,000 in September. Suitable land for tailings areas was then selected by the Arba mine manager and a land valuation obtained in April 1892 – the land being finally purchased after a protracted process taking 30 months.[43]

Meanwhile, the Arba and Ormuz Companies attempted to continue mining. The Arba was making preparations for pumping out the pit in August 1890, this taking six months to complete, enabling removal of the accumulated sludge to commence in June.[44] The director's patience was, however, exhausted: disposal of the property was endorsed six months later; all hands discharged the following month; and tenders called for the leases and plant in March.[45] In contrast, the Ormuz Co. were embarking on the introduction of new technology into Tasmania, that of a bucket elevator. In May 1891 the manager (William Wylie) of the Ross United Gold Mining Co. in New Zealand, and a director (Henry McKenzie) of Launceston ironworks Salisbury, Scott & Co. visited the mine, the latter tendering for the supply & installation of a 'ladder elevator with 25 buckets and 100 links and the necessary gear for driving from a water wheel' at a cost of £1,026.[46] It was trialled nine months later, a Daily Telegraph reporter witnessing:

> a new epoch in the life of tin mining in Tasmania … is simply a stationary ladder dredge working a massive framework of timber upon an inclined back. The buckets which are constructed of mild steel, are attached together by links and thus form an endless chain, which works over a top and bottom tumbler. The top tumbler is driven by spur and rope gearing from a stationary engine … the chain of buckets descend into a pit, scoop up their load of material and, ascending, deliver it over the top tumbler into fluming [sluice-boxes], where it is washed and separated.[47]

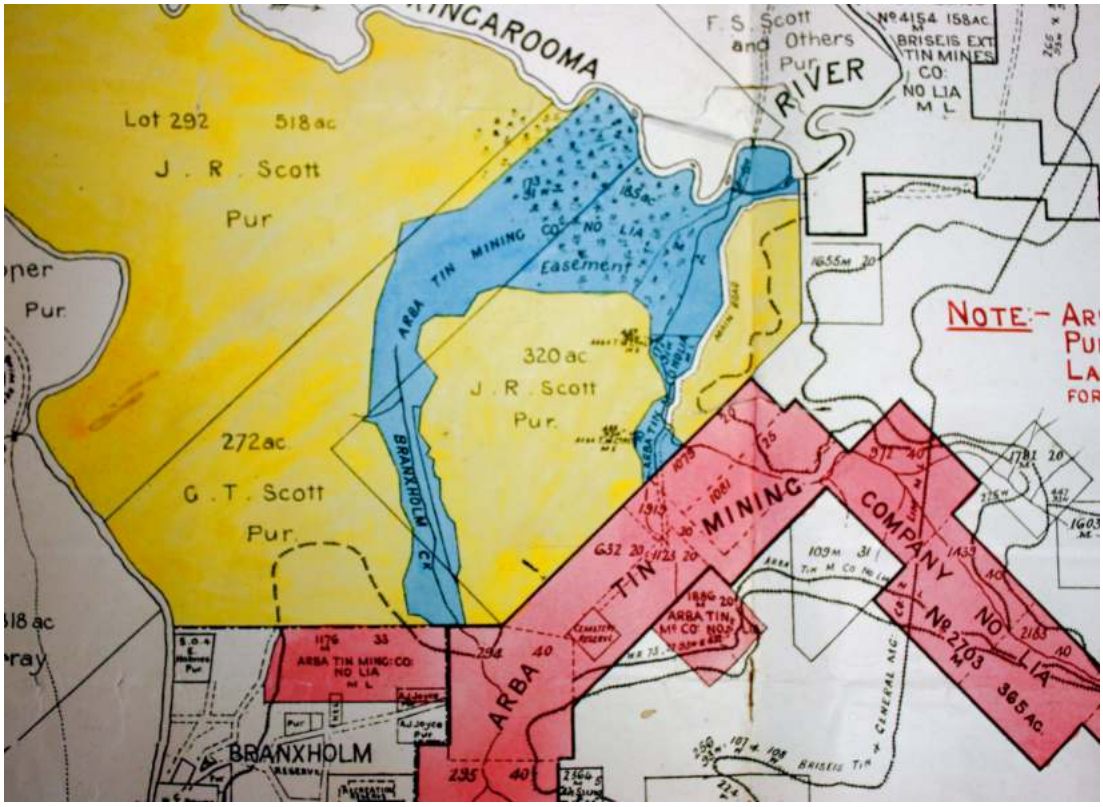
As a Hoskin giant nozzle was supplied by Anderson & Morrison of Dunedin, components of the elevator may also have been obtained from New Zealand. Given the problems with groundwater seepage into the Arba pit, steam power, rather than water power was adopted, a 10.5kW portable engine being acquired from the Mt. Victoria GM Co.[48] Total development costs were now £14,000 – this sum being raised from the original working capital of £4,000, calls on shares £6,500 and income from ore sales £3,437.[49]

Another dispute - 1892

Government purchase of 81.4ha of the Branxholm Estate landholding in April 1892 brought about a reversal of the Arba directors plans to sell the mine, for the following month Sam Hawkes notified the Lands Minister of a requirement for two mining easements on the Branxholm Estate. He divulged that almost £4,000 had been expended on 'royaltys, rents, damage at law & legal charges'. This was formalised within days as applications for a 75ha easement (as water right 173-91W) along Branxholm Creek (see Fig. 4) and a smaller area along the Black Creek to the northeast (WR 172-91W).[50] A complication now arose as the Ormuz Co. expected that previous access to the easement along Branxholm Creek would be maintained for their tailings disposal. The Secretary of Mines (Francis Belstead) made an urgent inspection of the mine the following month together with Mines Commissioner O'Reilly and Ormuz director Harry Conway. At the beginning of September, Sam Hawkes informed Belstead that the Ormuz Co. continued dumping tailings on the recently-purchased crown land, bringing a prompt rebuke from O'Reilly four days later prior to the issue of an injunction.[51]

With an election less than two months away, Belstead continued to manage the dispute instructing Public Works Department [P.W.D] engineer Robert S. Milles to find a solution to the Ormuz tailings disposal problem. He recommended a 250m extension of the Ormuz tailrace to avoid the tailings being discharged upstream of a narrow restriction of the valley sides.[52] With all work suspended, an agitated deputation of Ormuz directors greeted the newly appointed Lands Minister William Hartnoll, claiming that Milles's recommendation was unworkable 'as there was not fall enough to do the stripping' for future operations.[53] Hartnoll now called for a second opinion, engaging the Engineer-in-Chief of the P.W.D (James Fincham) representing the Government and consulting mining engineer William H. Cundy for the Ormuz Co. Despite producing an alternative scheme with a longer tailrace, which the Ormuz Co. favoured, Minister Hartnoll chose to retain Milles's scheme as the preferred option on the advice of the Secretary of Mines, who was liaising with Sam Hawkes.[54] Another deputation of irate Ormuz directors descended on the Minister in November, including John. C. Macmichael, who after re-iterating that Milles's scheme was unworkable, stated that 'he was speaking as a practical miner, having acquired experimental knowledge while the professional advisers of the Government were learning engineering'.[55] A final complaint by the Ormuz Co. legal secretary to the Secretary of Mines was referred to the embattled Hartnoll to defend the Lands Department's handling of the dispute – this released to the press two weeks later.[56]

Figure 4: *Tailings easements established on publicly-funded land.*



Source: Tasmanian Archive & Heritage Office, AB948/1/75, 24 June 1910.

With no further means of redress, the Ormuz directors complied with the requirements of Milles's design, tenders were called for the tailrace in December with the approval of the Secretary of Mines, and were completed in April 1893.[57] Costs of £412 were incurred during the eight-month

shutdown during which there was no tin production leading to a capital raising the following month.[58] As the mine was barely profitable due to a falling tin price, tribute working continued.[59] With the Arba vs Omuz dispute resolved, the statute book was tidied following passage of *The Mining Act, 1893* (57 Vict. No. 24), which encompassed all mineral mining for the first time and incorporated measures for tailings disposal.[60]

Stagnation and amalgamation 1893-98

From 1893 both the Arba & Ormuz Companies were battling to contain mining costs that resulted from an increasing working depth along the deep lead. The Ormuz was additionally constrained by working towards the Arba lease boundary. A further drainage tunnel was driven on the Arba lease through the highly pervious alluvial deposits towards Branxholm Creek in March – the extensive support requiring regular maintenance thereafter. Sam Hawkes was trialling an hydraulic elevator in August which appears to have been his last involvement with the mine as it was placed on the London market for sale and new directors were appointed five months later.[61] He was the last remaining member of the founding syndicate following the deaths of Edward Harrop in September 1891 and Capt. Urquhart in January 1894 – a one-fifth interest in the company auctioned in August 1896 marking the syndicate's demise.[62] All contract staff were laid off in April 1894 and tributing commenced the following month, the first call on shareholders since inception of one penny made in June.[63] Sam Hawkes was mining a claim at Ruby Flat by the end of year, an involvement that continued for some ten years before an hydraulic elevator was installed and the 60.75ha property sold to the Ruby Flat TM Co.[64]

Following Hawkes's departure, Ormuz manager John Roach became the driving force in maintaining output. Agreement with the Arba Co. for working the ground along the common lease boundary was reached in November 1894, the pumping costs to be shared and new waterwheel pumps installed on both leases to enable deeper mining to proceed.[65] As the bucket elevator was working at its depth limit of 18.5m, the Salisbury Foundry recommended an hydraulic elevator be used below the ladder dredge to raise wash into a wooden tank positioned:

> at the foot of the dredge from which the buckets take the dirt. The water that would get into the tank with the dirt could be pumped into pipes leading to the hydraulic elevator by a 10in. plunger pump worked from your waterwheel connected by a steel wire rope.[66]

The new plant was commissioned in March 1896, having consumed 50 per cent of the profit for the August half-year period, mining costs rising from £19 to £23 per ton due to the increased handling of washdirt.[67] As operating costs continued to increase, regular calls on shareholders exhausted the nominal capital of £12,000 early in 1897, the inevitable amalgamation with the Arba Co. proceeding in September.[68] Following transfer of the water right of the Ormuz race to the Arba Co. a year later, repairs were authorised and mining suspended in preparation for sale of the mine; the Ormuz race was to prove an essential component of future operations.[69]

A new start with Victorian capital 1899-1900

Chairmen of directors of the Arba (William G. Baird) and Ormuz (John C. Macmichael) Companies, both being stockbrokers and involved with a number of mining companies, pursued additional finance for mine development.[70] Negotiations were completed with the well-known

Melbourne consultant engineers Knox, Schlapp & Co. in February 1899, the re-financed company having a nominal capital of £19,200, a 54 per cent controlling interest secured in return for a sweetener of £1,000 to existing shareholders and the provision of £5,000 working capital.[71] As no public float was involved, a seamless transition took place, with Herman H. Schlapp proving to be a white knight through his long association with the mine.

Mine manager Edward Holmes was retained to pursue the mine expansion during the following year with 'operations confined to stripping overburden, continuation of drainage tunnel and also tailings easement' to enable hydraulic sluicing to proceed on Lease 632 to the northeast of the earlier workings.[72] A further 5 SH from Black Creek was procured and Hawkes's concept of a steam haulage incline revived but on a larger scale, powered by a Martin & Co. (Gawler) twin cylinder engine.[73] An increase of the nominal capital to £24,000 proceeded in May 1900 when new mine manager G.J. Bondry proposed increasing production by introducing a steam-driven, pontoon-mounted centrifugal pump which was trialled seven months later.[74]

Prolonged development before dividends commenced 1901-06

Further development was underway towards the end of 1901 when a new haulage incline (No. 1) was constructed, and tenders called for a 220m extension to the drainage tunnel. The new plant was commissioned three months later, whereby the gravel pump raised the washdirt 7.6m into settling bins positioned above the incline, these reducing the water-sand ratio from 30:1 to 4:1 before the washdirt was raised a further 29.0m to discharge into the tailrace.[75] Tin output was finally raised to 28.2t during the last quarter of 1902, this coinciding with increased tailings discharge into the Ringarooma River by the larger downstream mines (Ringarooma, New Brothers Home No. 1 & especially the Briseis TM).[76]

A petition to the Mines Minister in May 1901 supporting a move to designate the Ringarooma River a sludge channel was a thinly disguised attempt at procuring public funding for remediation works.[77] Danish civil engineer Karl L. Rahbek was engaged at the end of the following month to report on the tailings problem downstream of Branxholm. Before his report was finalised, snagging (dead tree or stump removal) was undertaken along the worst section of the river immediately downstream of the Briseis tailrace with immediate effect, 'the river is now lower than it has been for the past three or four years, and about 6ft or 7ft lower than this time last year'.[78] Further pressure from the Derby mine managers concerning public funding for river works produced only limited assistance, the Mines Department encouraging 'mine-owners to dump all their tailings on their claims'. The Briseis mine led the way, with mine manager Lindsay Clark instigating development of a stacked tailings area over a worked-out section of the mine that contained 114,680m^3 by June 1902 and double that by the end of 1903.[79]

Progress at the Arba was slowed by a series of events between 1904-06, commencing with unusually heavy summer rainfall (approximately 190mm) in February 1904, leading to flooding of the workings 'to a height of 10ft. above the drainage tunnel', that submerged the pump pontoon. De-watering of the pit took three weeks to complete, but a month later a 20m section of the pit wall slumped, cutting the headrace, 'the water from race flowed into the drainage tunnel, filling it with sand and soil for a length of nearly 600ft'. The support in the headrace tunnel failed at the beginning of March resulting in the entire 159m length being re-timbered, and in mid-June,

> one of shafts along the course of the drainage tunnel collapsed. The tunnel became blocked and it was necessary to take down an open-cut from the surface … tunnel opened and a new shaft now being raised.[80]

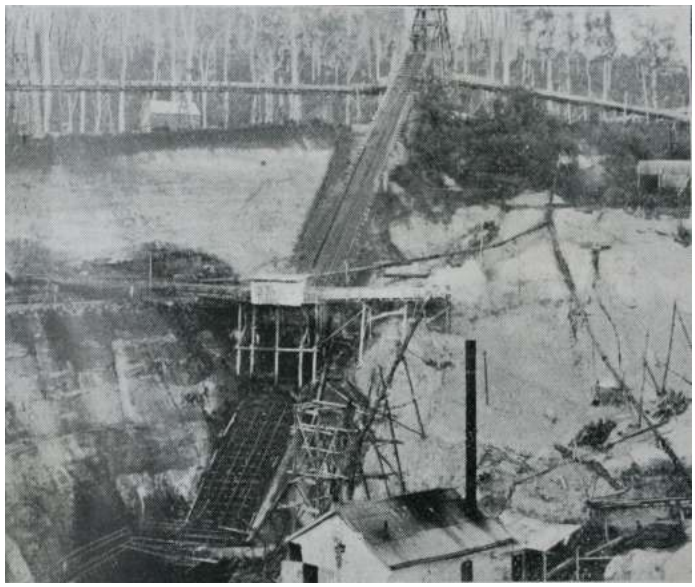
Following the appointment of a new mine manager in May 1905, NSW civil engineer Lewis Blayney Mitchell, annual production was raised to 103t tin but the mine was barely profitable, as working costs amounted to £400 per month. Despite this, the directors declared the first one-shilling dividend in February 1906, at a cost of £3,000.[81] Exceptional winter rainfall of approximately 990mm fell through May-July[82] causing extensive damage and loss of production. Manager Mitchell provided an account:

> heavy rains set in again on Jun 24, and continued up to 5 p.m. on Jun 25, causing the biggest flood ever seen in Arba Creek … the water came right over the road, 2ft. deep and 60ft. wide. As this was endangering the mine, I broke up the road metal so as to keep water in main channel.[83]

Increased fuel costs and water supply shortage 1907-09

A second steam-powered haulage incline (No. 2 – Fig. 5) was completed at the eastern end of the workings in August 1907, substantially increasing operating costs through firewood consumption of two additional boilers for the suction dredge and winding engine. Construction of a tramline from the southern lease boundary to convey firewood commenced 16 months later, reducing transport costs by two shillings per cord of two tons.[84] Contracts for the supply of 3-4,000 tons firewood were awarded each summer in preparation for the winter production, a team of 15-20 cutters required. As each dredge and winding engine required two cords per shift, consumption in 1914 amounted to approximately 40.5t per day for two-shift working. The labour cost was also substantial as four engine drivers were required per shift.[85]

Figure 5: *No. 2 Incline and pontoon – washdirt raised into settling bins extending across the incline for haulage to the surface.*



Source: *The Mining and Engineering Review*, vol. 5, July 1913, p. 397.

Flows in the Ormuz and Black Creek races were reduced (to 12 SH and 4 SH respectively) by early January 1909 due to an early start of the dry season, and two months later 'only about three heads in local races' was reported. At the January shareholders meeting, chairman Baird defended

the board's inaction by stating that 'additional sources [of water] were not available'.[86] This supply shortage had resulted from a major expansion of the Briseis mine between 1900-02, when the Mines Department engaged Rahbek to review water rights within the Ringarooma basin. Following gauging of summer flows along the Maurice and Ringarooma Rivers, the Briseis mine was granted an unprecedented 100 SH (equivalent to 98.4ML per day) to add to their existing entitlements of 129 SH from the Cascade River and Main Creek to the northeast. Arba's pre-existing entitlement to 25 SH from the Dorset River was retained despite the considerable influence of the British-financed Briseis mine that had a capitalisation of £600,000.[87]

More tailings litigation 1910-11

Following the merger with the Ormuz Co, tailings were stacked on their ground until they were washed into Branxholm Creek during the February 1904 floods. During 1905 a replacement tailings dump on the Arba lease was progressively extended until the winter floods of 1906 'carried away the greater portion of the dump'. In 1908 surveyor Donald Fraser estimated that 258,420m^3 tailings had been deposited to a depth of 0.9m over a 25ha area of the Branxholm Estate, along the northern side of tailings easement 173-91W.[88] The Arba Co. resorted to purchasing 4ha of the Branxholm Estate in July for £300 for continued tailings disposal, this about five times the valuation of good pastoral land. Further conflict with Scott's trustees stemmed from a requirement for yet more land for tailings disposal, the Arba management approaching the Mines Department for resolution in January 1910.[89] In June, Mines Inspector Michael J. Griffin was directed to determine the extent of tailings encroachment to enable compensation to be assessed. Scott's trustees were informed of a Cabinet decision three months later: 25 per cent of the costs to be paid by Arba Co, 25 per cent by Scott's Estate 'as practically all further works of the Arba Co will be on their private land', 25 per cent from public expenditure and 25per cent by the remaining mines along the Branxholm and Black Creeks.[90]

Before the Government directive could be implemented, Scott's trustees obtained a restraining order in August 1908 against further tailings discharge onto the Estate's land. The dispute reached the Supreme Court in November 1910, when reparation of £2,000 was sought. Damages of £330 were awarded, this being approximately half the land valuation prepared by Griffin.[91] Another claim by surveyor Don Fraser for similar damages was heard in the Supreme Court nine months later; he purchased 121.5ha of land fronting the northern bank of the Ringarooma River at auction in December 1904 for £1,050.[92] Arba manager Mitchell claimed that since November 1910 practically all (97-98 per cent) tailings were deposited in old workings, while some 26.75-30.5m^3 of tailings was washed into Arba's dam daily from upslope mines. Despite Mitchell's testimony, further damages of £160 were awarded to Fraser, the Arba Co. paying a high price for the Government's inability to produce effective legislation for regulating tailings disposal.[93]

Record production before large-scale mining ceased 1911-20

Planning for further mining on the Branxholm Estate was well advanced by mid-1912 when the northern tailings lease was surrendered to enable a mineral lease to be granted, referred to as the *Easement Lease*. Reserves of 535,000m^3 averaging 1.12kg/m^3 (599t) were estimated from drilling at depths of up to 9.15m.[94] A third pontoon was equipped with a gravel pump and telescopic suction

pipe fitted with a revolving Von Schmidt cutter head, electrically powered from a generator located adjacent to the newly-completed No. 3 Incline (Fig. 6) on the western side of Arba Hill. Because teething problems could not be overcome, a gravel pump of conventional design was substituted, this being finally operational in July 1914 at a cost exceeding £4,000.[95] This coincided with the onset of difficult operating conditions brought about by a severe fall in the tin price after the commencement of WW1. An attempted 33 per cent reduction of the miner's wage rate led to a shutdown in October; the winter rains also failed, the 1914 rainfall being some 28 per cent below the mean value, when all of the headraces were reported to be 'practically dry'.[96]

A rapid increase in production after a resumption of sluicing in April 1915 enabled dividend payments to re-commence in mid-1916.[97] Elevated rainfall led to a record output of 180.3t tin in 1916 and 145.3t the following year, a rising tin price generating consistent half-year profits, which peaked at £9,600 in December 1917.[98] This was largely achieved by working the Easement Lease, which offset the rapidly declining reserves of the deep lead. The shareholders were informed at the August 1918 meeting that the mine was 'nearing the end of its life, and the directors sooner or later would have to acquire some other property'. As the search for suitable mines was unsuccessful, further profits were returned to shareholders in monthly dividends towards the end of 1918.[99] With the mine in decline, Scott's trustees, having milked the mining industry for 30 years, auctioned most of their remaining landholdings adjoining the Arba leases in February 1919.[100] Tin deposits on the Easement Lease were exhausted ten months later, when surplus machinery was sold off and the last reserves from the deep lead were worked from the No. 3 incline.[101] Production records for June 1903 - December 1920 indicate a total output of 1,850t tin oxide at an average grade of approximately 0.6kg/m^3 including 280t from the Easement Lease, this was less than half of the 1912 estimate of reserves.[102]

Figure 6: *Headframe for steam winding engine on the No. 3 Incline. Figure in the foreground possibly mine manager Mitchell.*

Source: University of Tasmania, Branxholm W2, date unknown.

Small operators clean up 1921-60

The Arba directors realised that further revenue could be generated by re-working the leases on tribute, so these were consolidated and all water rights to 52 SH (see Appendix 1) retained, including the most valuable asset, the Ormuz race.[103] Two main parties were to dominate mining for the following 39 years: the Walsh brothers (Ollie, Bill and Sam) using hydraulic sluicing in conjunction with an elevator supplied by a 915m long pipe column from the Ormuz race, and Percy W. Edwards using a 200mm gravel pump driven by 15kW Marshall portable steam engine.[104] Edwards also obtained additional water rights from tributaries of Branxholm Creek.[105] A further period of dividend payments commenced in mid-1925, indicating that profits (after royalty payments) exceeded £1,500 per year from an annual production of 20-46t.[106] A setback occurred in April 1929 when devastating floods that affected much of northern Tasmania had a significant impact on the mines along the Ringarooma valley. The Arba leases escaped lightly, but the Walsh brothers had a damages bill of £2,000 to replace earthworks, culverts, head and tailraces and to unearth the elevator. Construction of a pipe column and water race from the Briseis headrace by Edwards twelve months later may also have been instigated by flood damage.[107]

Few changes were made to the Arba board of directors from its formation: chairman Baird's death in 1937 ended a 44-year association with the company, while Herman Schlapp was re-elected five months later, shortly before his death at the age of 84.[108] A final dividend was awarded in November 1943 before the last of the Arba water rights was declared void in mid-1954: that of the Ormuz race after some 65 years of continuous use. Government purchase of the Briseis water race through the provisions of the *Ringarooma & Cascade Water System (Agreement) Act of 1947* (11 & 12 Geo VI. No. 97) ensured a water supply for the Arba leases until it was abandoned at the end of 1960. This finalised accumulated Government losses of nearly £60,000.[109]

Table 1: ***Production Summary***

Date	Tin Oxide (t)	Metallic tin (t)	Notes
1877 -84	c195	c135	Celt workings on Branxholm Estate, from shipping reports.
1877-88	c1,230	c860	Arba leases, from shipping reports.
1888-98	n.d.	n.d.	Tribute working.
1899-1903	c190	c135	From MRT 'The progress of the Mineral Industry' quarterly reports.
1904-20	1,850	1,295	From 'Reports of the Secretary of Mines'& shareholder's reports.
1921-60	>825	>580	From 'Reports of the Secretary of Mines', no details for 1930 & 1931.
TOTAL	>4,290	>3,005	

Conclusion

Total output of metallic tin exceeding 3,000t (see Table 1) over an extended 85-year period places the Arba mine as the fourth largest producer in the Ringarooma basin.[110] Periods of healthy profits were limited to the initial development phase (at shallow depth) between 1877-88, when the mine was privately owned, and 1905-17 (apart from the onset of WW1) when an elevated tin price prevailed and high production levels were maintained. Tin production was constrained by a number of factors emanating from the challenging geomorphology, historical land grants that pre-dated mining, the depth of the tin deposits, drainage measures required to combat groundwater inflows,

limited water rights and the inability of legislators to address tailings disposal efficiently.[111] Mine managers had to implement expensive work practices to overcome these constraints, notably the use of steam power for pumping and haulage, accompanied with high running costs. Consequently, total dividend payments between 1906-43 were limited to less than 1.5 times the capitalisation of £24,000, leading to shareholder dissatisfaction.

In the late 19th century few options were available for raising alluvial deposits from open cut excavations once the depth exceeded 18-20m, which was the limit for gravel pumps or single-lift bucket or hydraulic elevators to raise washdirt. The steam-powered haulage incline developed at the Arba was also adopted by the nearby Ringarooma mine, and briefly at the Pioneer mine, but was found to be uneconomic at these mines.[112] The nearby Briseis mine with water rights to 278 SH (over five times that of Arba) by September 1924, was able to utilise waterpower extensively to power gravel pumps and elevators, and consequently, was highly profitable prior to the destruction wrought by the 1929 floods.[113]

Tailings disposal in the Ringarooma basin first became a significant problem in 1884 when the Arba mine management was forced to negotiate with private landowners. Poorly framed legislation prior to the 1893 Mining Act proved ineffective in addressing the competing interests of agriculture and mining. The Tasmanian model left the courts to rule on compensation for land degraded by tailings, the mining companies vulnerable to claims from landholders without time limitation and irrespective of the distance involved; claims being made over a 25-year period (Arba mine) and for deposition in excess of 50km from the source of tailings (Briseis mine).[114] In Victoria, 1884 legislation established a framework for compensation for land affected by tailings prior to mining proceeding, a more equitable system that avoided expensive litigation.[115] Further, 1904 legislation in Victoria established a Sludge Abatement Board to regulate the offsite disposal of tailings by enforcing threshold levels for suspended solids, but this *control at source* approach was not adopted by Tasmanian legislators.[116] The Victorian approach has stood the test of time and remains the standard method to this day.

A policy in Tasmania of locating tailings dumps on worked-out ground had been introduced by the larger mines early in the 20th century, encouraged by the Mines Department in order to limit potential public funding of remediation works. This proved to be flawed in practice as tailings dumps were generally located within the flood plain and consequently were swept into the river channel during the major storm events of 1906, 1929 and 1936, when large quantities were conveyed to the lower section of the river. Total metallic tin production from the Ringarooma basin has been estimated at 44,500t generating about 40.85 million cubic metres of tailings, of which total the Arba mine contributed approximately 7.6 per cent. Although the upper reaches of the Ringarooma River (including the Arba section) had regained the former bed level by 1990, based on computer modelling it has been estimated that the accumulated tailings between Moorina and Gladstone (up to 12-13m in depth) will not be removed until at least 2040, depending upon the magnitude and frequency of flood events. This research, completed 25 years ago, now appears highly optimistic.[117]

Acknowledgements

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Appendix 1: *Summary of Water Rights*

Ref. No.[1]	Source	Application Date	No. SH[2]	Length (m)	Applicant
Arba & Ormuz Companies					
73 + 74W	Black Creek	7/3/1888	12	c2,850	Sam Hawkes
27-93W		28/8/1894	+8		Arba TM
432-93W		12/10/1899	+5		
131-87W	Dorset River	19/3/1888	25	11,795	Ormuz TM
345-93W		11/5/1899		+136	Arba TM
241-87W	Maggs Creek	27/12/1889	1	c40	Ormuz TM
242-87W	Boulder Creek		1	c40	
		TOTAL	52		
Tribute Working					
2115W	Branxholm Creek	12/2/1920	10	>450[3]	Percy Edwards
2387W	Snapper Creek	7/12/1925	3	>800[3]	

Notes:

(1) Mines Department registers of water race applications (TAHO MIN90).

(2) SH = Sluice-head (Tasmanian), equal to 0.68 cubic metres per minute or 41.1 kilolitres per hour.

(3) Length to southern boundary of Branxholm Estate.

Endnotes

[1] F.L.N. Ling, 'River modelling for Tasmania, vol. 3: the Pipers-Ringarooma region', *CSIRO*, December 2009, p. 4.
[2] J.G. Purvis & Associates, 'Tasmanian tin prospects, Part 2 – N.E. Tasmanian Tin Province', November 1988, p. 32, *Mineral Resources Tasmania* [hereafter *MRT*].
[3] *The Mercury*, 8 January 1875, p. 2: Mount Bischoff smelter commenced operation; *Launceston Examiner*, 22 January 1876, p. 2; *ibid*., 1 July 1876, p. 2.
[4] M. Szalay, *Tasmania Bound: the Weymouth, Hubbard, Harris & McPhail families in Australia*, Cremorne, 2004, p. 462: Weymouth & McPhail partnership formed 1868. McPhail became Weymouth's brother-in-law through marriage.
[5] *Launceston Examiner,* 15 August 1876, p. 2; *ibid*., 13 January 1877, p. 5; *ibid*., 4 May 1882, p. 3; *Daily Telegraph*, 16 February 1889, p. 3; Arba = Hebrew for *four*.
[6] *Cornwall Chronicle*, 6 April 1877, p. 2; no details are known of the share distribution among the syndicate members.
[7] *Hobart Gazette*, 10 May 1881, p. 960: Lease 294 registered to G. Weymouth & Lease 295 to A. McPhail, dated 1 November 1876; *Launceston Examiner*, 25 March 1882, supplement p. 1.
[8] 'General correspondence: Branxholm Tailings Area', AB948/1/41, 12 January 1878, *Tasmanian Archives & Heritage Office* [hereafte]; *Launceston Examiner,* 3 July 1877 p. 3: output 3.75t tin oxide from Celt workings to June.
[9] *Cornwall Chronicle*, 30 July 1878, p. 2; *Launceston Examiner,* 16 August 1878, p. 3. For Hawkes see Greg Dickens, 'The Mount Cameron Water Race Board – a history of management', *MRT* 1992/21, p. 3.
[10] 'Register of the issue of mineral leases', *TAHO*, MIN120/1/1: Hawkes granted 8 SH [sluice-head] as WR 73 & 4 SH as WR 74 for Section 294, 1 August 1883; 'Registers of applications for water rights', MIN90/1/2: application for additional 8 SH as WR 27-93W dated 28 August 1894 and further 5 SH as WR 432-93W dated 12 October 1899.
[11] *The Mercury,* 10 March 1881, p. 2; *Launceston Examiner,* 17 September 1881, p. 3; *ibid.*, 15 October 1881, supplement p.1; *ibid*., 29 October 1881, supplement p. 1.
[12] G. Thureau, 'An interim report on some of the more prominent stanniferous deposits in the vicinity of the Ringarooma River', *MRT*, OS052, February 1884, p. 1.
[13] 'Grant to James Reid Scott', *TAHO*, NS52/1/28, Book 47, No. 9635: original land grant of 209.8ha, 28 June 1860; for Scott see *Australian Dictionary of Biography* [hereafter *ADB*], vol. 6, pp. 96-7, Melbourne University Press, 1976.
[14] *The Mineral Lands Act 1884* (47 Vict. No. 10) came into effect on 31st December 1883 for mining leases other than for gold: Section 48 made provision for a *mining easement* to be granted only on crown land for the construction of 'drains, tailraces, sludge channels', Section 50 included provision for compensation to the affected lease holders.
[15] AB948/1/41, 6 January 1885, *TAHO*.
[16] Ralph Birrell, *Staking a Claim: Gold and the Development of Victorian Mining Law*, Melbourne University Press, 1998, pp. 103-04.
[17] A.C. Veatch, 'Mining Laws of Australia and New Zealand', in *Bulletin 505*, *United States Geological Survey*, Washington, 1911. All States except Tasmania and Queensland followed Victoria's lead in drafting legislation for mining on private land – South Australia in 1888, NSW in 1894, Western Australia in 1897.
[18] *The Mercury,* 18 August 1882, supplement p. 2; *ibid*., 27 July 1883, p. 3; *Daily Telegraph,* 14 May 1884, p. 3.
[19] *Launceston Examiner,* 11 June 1883, p. 3; *ibid*., 2 September 1884, p. 3.
[20] *Ibid*., 16 February 1885, p. 3.
[21] *Daily Telegraph,* 3 August 1886, p. 3; *Cornwall Chronicle,* 25 July 1877, p. 3: first recorded use of a trommel in Tasmania by Ferd Kayser at the Mount Bischoff mine.
[22] Ibid., 9 September 1886, p. 3.
[23] *Launceston Examiner,* 16 February 1885, p. 3; *Australian Town & Country Journal*, 2 October 1886, p. 25.
[24] *Ibid.*, 30 March 1888, p. 2.
[25] *Ibid.*, 28 February 1887, p. 3; *ibid*., 13 August 1887, p. 3; *ibid*., 27 August 1887, p. 3; *The Mercury,* 26 March 1887, p. 3.
[26] www.parliament.tas.gov.au/history/tasparl/fyshp94.htm: elected 30 March 1887.
[27] *The Mercury,* 8 September 1887, p. 3; *ibid*., 9 September 1887, p. 3; *ibid*., 17 September 1887, supplement p. 2; *ibid*., 30 March 1888, p. 2.
[28] *Launceston Examiner,* 22 March 1888, p. 2; *ibid*., 23 March 1888, p. 3; *ibid*., 26 March 1888, p. 3.
[29] SH = Sluice-head (Tasmanian), equal to 0.68 cubic metres per minute or 41.1 kilolitres per hour.

[30] MIN90/1/1, 19 March 1888, *TAHO*: E. Allen application for 25 SH as WR 131-87W; *Launceston Examiner,* 23 April 1888, p. 3; *ibid*., 26 April 1888, p. 4; *Hobart Gazette,* 16 May 1888, p. 876: Robert Carter the legal secretary.
[31] *Launceston Examiner,* 26 April 1888 p. 4; S.P. Ellis, 'Survey plan of Application 131-87W', Dorset: Book 17 - Survey 4, *MRT*, 12 September 1888.
[32] *Ibid*., 30 November 1888, p. 3; *ibid*., 23 April 1889, p. 3; *ibid*., 31 May 1889, p. 3; 'Applications by mining companies for registration', 30 October 1889, MIN66/1/59, *TAHO*.
[33] *Ibid*., 12 June 1888, p. 4; *ibid*., 18 September 1888, p. 2: George Weymouth no longer involved as he was dying from cancer, aged 45, the partnership with Alexander McPhail was dissolved 18 months earlier.
[34] Tin output for Arba and Celt workings estimated from shipping reports, an average tin price of £47 per ton used.
[35] *Daily Telegraph,* 16 February 1889, p. 3; *ibid*., 23 August 1888, p. 4.
[36] *Launceston Examiner,* 20 December 1889, p. 3.
[37] *The Mercury,* 7 September 1889, p. 4; *ibid*., 2 October 1889, p. 3;
[38] *Ibid*., 30 October 1889, p. 3; *Launceston Examiner*, 6 November 1889, p. 2.
[39] *Launceston Examiner,* 3 September 1889, p. 3; *ibid*., 29 November 1889, p. 3; *ibid*., 20 December 1889, p. 3.
[40] *Ibid*., 21 December 1889, p. 3; *ibid*., 17 January 1890, p. 3; *Daily Telegraph,* 23 December 1889, p. 3.
[41] *Ibid*., 12 March 1890, p. 3; *ibid*., 10 May 1890, p. 3.
[42] *The Mercury,* 19 October 1889, Supplement, p. 1; *Launceston Examiner,* 2 November 1889, p. 3; AB948/1/41, 14 April 1890, *TAHO*.
[43] The *Mercury*. 5 September 1890, p. 4; 'Purchase of Land for Mining Easements', *The Public Works Construction Act 1890* (54 Vict. No. 18) enacted 15 November 1890.
[44] *The Mercury,* 21 August 1890, p. 4; *ibid*., 15 April 1891, p. 3; *Launceston Examiner,* 6 June 1891, p. 3.
[45] *The Mercury*, 3 January 1892, p. 1; *ibid*., 30 March 1892, p. 3; *Launceston Examiner,* 26 February 1892, p. 4.
[46] *Launceston Examiner,* 29 May 1891, p. 3; *ibid*., 27 November 1891, p. 3; Salisbury Foundry Collection, Launceston Queen Victoria Museum, CHS35, 8 June 1891, p. 397.
[47] *Daily Telegraph,* 21 May 1892, p. 5; see Otago Witness, 18 December 1890, p. 12, for a detailed description of the Ross United GM Co. bucket elevator driven by a Whitelaw turbine.
[48] *The Mercury,* 27 November 1891, p. 4; *Daily Telegraph,* 4 April 1892, p. 3; *Journals of the House of Representatives, Tasmania* [hereafter *TPP*], vol. 6, no. 59, December 1884, p. 10.
[49] AB948/1/41, *TAHO*, 27 May 1892: the water supply race and elevator accounted for 50 per cent of the expenditure.
[50] *Ibid*: Hawkes to Mines Minister Pillinger, 26 May 1892; MIN90/1/1, 31 May 1892, *TAHO*; *Launceston Examiner,* 15 October 1892, p. 3.
[51] *Ibid*: Carter to Pillinger, 27/5/1892; Hawkes to Hartnoll, 2 September 1892; O'Reilly to Carter, 6 September 1892.
[52] *Ibid*: Milles to Belstead, 2 August 1892; *The Mercury*, 18 June 1925, p. 7: Milles AMICE, studied engineering at King's College, London, resigned following completion of the Ormuz report to be engaged by Hobart City Council.
[53] *Launceston Examiner,* 13 September 1892, p. 3; *ibid*., 29 November 1892, p. 4.
[54] AB948/1/41: Hawkes to Belstead, 12 December 1892, *TAHO*; *The Mercury*, 20 July 1914, p. 4: Fincham MICE, employed as engineer of the Hobart-Launceston Main Line Railway before being appointed the first Engineer-in-Chief of the P.W.D in April 1877.
[55] *Ibid*: Fincham & Cundy to Hartnoll, 25 October 1892; *Launceston Examiner,* 29 November 1892, p. 4.
[56] *Daily Telegraph*, 20 December 1892, p. 1; C.A. Bacon, 'A brief history of the Department of Mines – 1882 to 2013', November 2013, p. 2, *MRT*: the Secretary of Mines reported to the Minister of Lands & Works until the office of the Minister for Mines was created in 1894.
[57] *The Mercury,* 10 January 1893, p. 3; *Launceston Examiner,* 17 February 1893, p. 6; *ibid*., 4 April 1893, p. 4; AB948/1/41: Belstead to Carter, 8 February 1893, *TAHO.*
[58] *Daily Telegraph,* 1 December 1892, p. 5; *Launceston Examiner,* 1 June 1893, p. 6; MIN66/1/159, 31 May 1893, *TAHO*: nominal capital increased by £4,000 to £12,000.
[59] *Launceston Examiner,* 4 April 1893, p. 4; *ibid*., 1 June 1893, p. 6; the price of tin oxide fell from £62 per ton in 1888 when the mine commenced to £51 per ton in 1892, decreasing further to a low of £34 per ton in 1896 – a 45 per cent reduction.
[60] *The Gold Fields Regulation Act, 1880* (44 Vict. No. 16), *The Mineral Lands Act, 1884* (47 Vict. No. 10), together with the three Acts passed between 1887-89 to address mining on private property, were all repealed.

[61] *Launceston Examiner,* 7 March 1893, p. 8; *ibid*., 28 August 1893, p. 6; *The Mercury,* 31 January 1894, p. 3,
[62] *Ibid*., 9 September 1891, p. 3; *ibid*., 15 January 1894, p. 3; *ibid*., 29 August 1896, p. 12; M. Szalay, p. 441: McPhail was established as a commission agent in Melbourne by 1894.
[63] *The Mercury*, 25 April 1894, p. 3; *ibid*., 6 June 1894, p. 11; *Launceston Examiner,* 28 May 1894, p. 2.
[64] *Launceston Examiner,* 26 October 1894, p. 7; *Examiner,* 6 April 1905, p. 2; ibid., 15 September 1906, p. 7.
[65] *Ibid*., 3 November 1894, p. 4; *ibid*., 12 November 1894, p. 6; *ibid*., 1 December 1894, p. 7.
[66] Salisbury Foundry Collection, CHS35: Salisbury Foundry to Robert Carter, 6 December 1896.
[67] *Launceston Examiner,* 30 November 1895, p. 7; *ibid*., 23 March 1896, p. 7.
[68] MIN66/1/459, 31 May 1893, *TAHO*; *Hobart Gazette*, 5 January 1897, p. 205: final 1d (penny) call; *The Mercury* 3 September 1897, p. 1.
[69] MIN90/1/2: transfer 25 SH as WR 55-93W dated 23 September 1898, *TAHO*; *Launceston Examiner,* 3 October 1898, p. 3; *ibid*., 14 October 1898, p. 8.
[70] *Examiner,* 30 August 1937, p. 7: following Edward Harrop's death in 1891, William Gunning Baird became manager of the Launceston office of the Commercial Bank of Tasmania Ltd; *The Mercury*, 31 January 1894, p. 7: Baird appointed an Arba director; for Macmichael see *Cyclopedia of Tasmania*, vol. 2, p. 130.
[71] *Launceston Examiner,* 23 February 1899, p. 2; *ibid*., 17 March 1899, p. 8; for William Knox see *ADB* , vol. 9, Melbourne University Press, 1983, p. 590; for Herman H. Schlapp see *ADB,* vol. 11, pp. 537-38.
[72] MININD December 1899, p. 6, *MRT*; MIN90/1/3: application for a 'boxed tailrace' within Easement 172-91W as WR 488-94W dated 12 February 1900, *TAHO*.
[73] *Examiner,* 28 March 1900, p. 3; MIN90/1/3: lease for additional 5 SH as WR 432-93W dated 1 June 1900, *TAHO*.
[74] *Ibid*., 21 May 1900, p. 8; *ibid*., 25 January 1901, p. 2.
[75] *Ibid*., 27 November 1901, p. 2; *ibid*., 15 March 1902, p. 13; *TPP*, vol. 47, no. 13, 18 September 1902, p. xxxix: incline capacity 650m^3 per day.
[76] MININD, September 1902, p. 8: output 8.2t; *ibid.*, December 1902, p.10, *MRT*.
[77] *Examiner*, 27 May 1901, p. 2; for further details see Glyn Roberts, *Metal Mining in Tasmania 1804 to 1914*, Bokprint Pty Ltd, 2007 p. 298.
[78] *Daily Telegraph,* 29 October 1901, p. 4; K.L. Rahbek, 'Inspection of the Ringarooma River from Branxholm to Boobyalla', *MRT* OS180A, 8 November 1901.
[79] *TPP,* vol. 47, no. 13, 18 September 1902, p. xlii; *The Mercury*, 11 September 1903, p. 2.
[80] *Examiner*, 29 February 1904, p. 2; *ibid*., 30 July 1904, p. 3; 'Results of rainfall observations made in Tasmania', *Commonwealth Bureau of Meteorology*, 1936, p. 55: 187mm rainfall recorded at Ringarooma in February 1904.
[81] *Ibid*., 29 May 1905, p. 2; *ibid*., 8 February 1906, p. 1: five dividends distributed through to November 1912 totalling 3s 6d; *Daily Telegraph* 5 February 1906, p. 2.
[82] *Commonwealth Bureau of Meteorology*, 1936, p. 55: rainfall 35 per cent above the 37-year mean.
[83] *Examiner,* 4 July 1906, p. 2; *ibid*., 28 July 1906, p. 4.
[84] *Ibid.,* 28 July 1907, p. 2; *ibid*., 28 July 1909, p. 2: 1.2km tramline; *The Mercury*, 24 December 1908, p. 7.
[85] *Ibid*., 10 February 1909, p. 2; *Daily Telegraph,* 1 August 1914, p. 4: firewood cost £1,150 for 2,000 cords.
[86] *Ibid*., 29 January 1909, p. 2; *ibid*., 25 March 1909, p. 2.
[87] *The Cyclopedia of Tasmania*, 1899, p. 512; K. L. Rahbek, 'Water-rights, Ringarooma River', *TPP,* vol. 43, no. 62, , 25 September 1900; H.V. Champion, 'The Briseis Water Race', *Proc. Victorian Institute of Engineers*, vol. 4, 1902, p. 21.
[88] *The Mercury*, 16 November 1910, p. 2; *ibid*., 17 November 1910, p. 2; AB948/1/75, 'Correspondence: Scott's Estate v Arba Co.', 24 June 1910; *TAHO*.
[89] *Examiner,* 28 July 1908, p. 2; *Daily Telegraph,* 29 January 1910, p. 4.
[90] AB948/1/75, 14 September, *TAHO*.
[91] *The Mercury*, 16 November 1910, p. 2; *ibid*., 17 November 1910, p. 2; *Examiner,* 1 February 1911, p. 2; AB948/1/75, 24 June 1910, *TAHO*.
[92] NS786/1/123, 'Plan of subdivision of Branxholm Estate', 1 December 1904, *TAHO*.
[93] *Examiner,* 24 August 1911, p. 3; *ibid*., 6 September 1911, p. 7.
[94] MIN90/1/2: tailings lease 173-91W surrendered 18 July 1912, *TAHO*; *TPP,* vol. 69, no. 6, March 1913, p. 16.

[95] *Examiner,* 1 February 1913, p. 4: 'No. 3 incline completed', *ibid*., 30 July 1913, p. 2; *ibid*., 31 July 1914, p. 2; *The Mining & Engineering Review,* vol. 5, July 1913, p. 398: other suction dredging plants steam-driven, No. 1 fitted with an Austral Otis 305mm pump & No. 2 with Thompsons 255mm gravel pump and 305mm nozzle pump.
[96] *Daily Telegraph,* 22 September 1914, p. 3; *Examiner,* 3 October 1914, p. 3; *Commonwealth Bureau of Meteorology*, p. 55: 37-year mean value for Ringarooma = 1236.5mm; *TPP*, vol. 73, no.11, May 1915, p. 17.
[97] *TPP,* vol. 75, no. 14, May 1916, p. 14; *The Mercury*, 22 July 1916, p. 1: ten dividends distributed through to November 1918, totalling 5 shillings.
[98] *Commonwealth Bureau of Meteorology*, p. 55: rainfall of 1,734mm in 1916 and 1,847mm in 1917, some 40-49% above the 37-year mean value; *TPP,* vol. 77, no. 7, May 1917, p. 15; *ibid*., vol. 79, no. 13, June 1918, p. 13; *Examiner*, 30 January 1918, p. 2.
[99] *TPP,* vol. 77, no. 7, May 1917, p. 15: tin from Easement Lease formed 42 per cent of total output; *ibid*., vol. 79, no. 13, June 1918, p. 13: 68.4 per cent of output from the Easement Lease; *Examiner,* 1 August 1918, p. 8; *ibid*., 1 February 1919, p. 12.
[100] *Examiner,* 1 February 1919, p. 12.
[101] *The Mercury*, 14 October 1919, p. 2; *Examiner,* 31 January 1920, p. 4.
[102] *TPP,* vol. 83, no. 5, May 1920, p. 10; P.B. Nye, 'The Sub-Basaltic Tin Deposits of the Ringarooma Valley', *Geological Survey Bulletin* [hereafter *GSB*], no. 35*,* September 1924, p. 35.
[103] *GSB,* no. 35*,* September 1924, p. 33.
[104] *Daily Telegraph,* 17 April 1923, p. 2; *ibid*., 13 June 1923, p. 2; *The Mercury*, 18 October 1928, p. 5.
[105] MIN90/1/6: P.W. Edwards application for 10 SH as WR 2115W from Branxholm Creek, 12 February 1920; *ibid*., P.W. Edwards application for 3 SH & 4.5ha dam as WR 2387W on Snapper Creek, 7 December 1925, *TAHO.*
[106] *The Mercury*, 6 June 1925, p. 16: four dividends distributed through to June 1927 totalling 2 shillings and five totalling 1 shilling between Dec 1932-Jan 1943.
[107] *Examiner,* 24 April 1929, p. 10; *The Mercury*, 4 August 1930, p. 5: pipe column part of WR 2387W.
[108] *Ibid*., 30 August 1837, p. 7; *ibid*., 29 January 1938, p. 6; *ADB,* vol. 11, pp. 537-38.
[109] *The Mercury*, 13 November 1943, p. 17; 'Annual Report', AR1956, p. 27, & AR1960, p. 11, *MRT*.
[110] *J.G. Purvis & Associates*, p. 32: total metallic tin output at Briseis mine - 21,140t; Pioneer & Argonaut - 9,750t; Endurance - 3,500t.
[111] *GSB*, no. 35, p. 33: the pit wall fronting Arba Hill reached 53.7m in height by 1920.
[112] *Launceston Examiner,* 3 July 1889, p. 3; *The Mercury*, 21 August 1890, supplement, p. 2.
[113] *GSB*, no. 35, September 1924, pp. 46 & 48: total dividends of £502,500.
[114] *Daily Telegraph*, 11 September 1903, p. 3; tailings deposition on Alfred Parker's land on the Ringarooma River located some 50km downstream of the Briseis mine – only £5 damages awarded by the Supreme Court; *ibid*., 21 December 1904, p. 16: judgement of further action by the same litigant in favour of the defending mining companies.
[115] Birrell, *Staking a Claim*, p. 105: *Mining on Private Property Act 1884* amended in 1888 to include Crown land held under lease (52 Vict. no. 998).
[116] Section 60 of the *Mines Act 1904* (4 Edw. VII. no. 1961) provided for sludge generated by hydraulic mining, dredging and sluicing; see Susan Lawrence & Peter Davies, 'The Sludge Question: the Regulation of Mine Tailings in Nineteenth-Century Victoria', *Environment & History*, vol. 20, 2014, pp. 396-401 for the evolution of tailings legislation.
[117] *P.G. Purvis & Associates*, p. 3; A.D. Knighton, 'River adjustment to changes in sediment load: the effects of tin mining on the Ringarooma River, Tasmania, 1875-1984', *Earth Surface Processes and Landforms*, vol. 14, 1989, pp. 339, 347 & 358.