

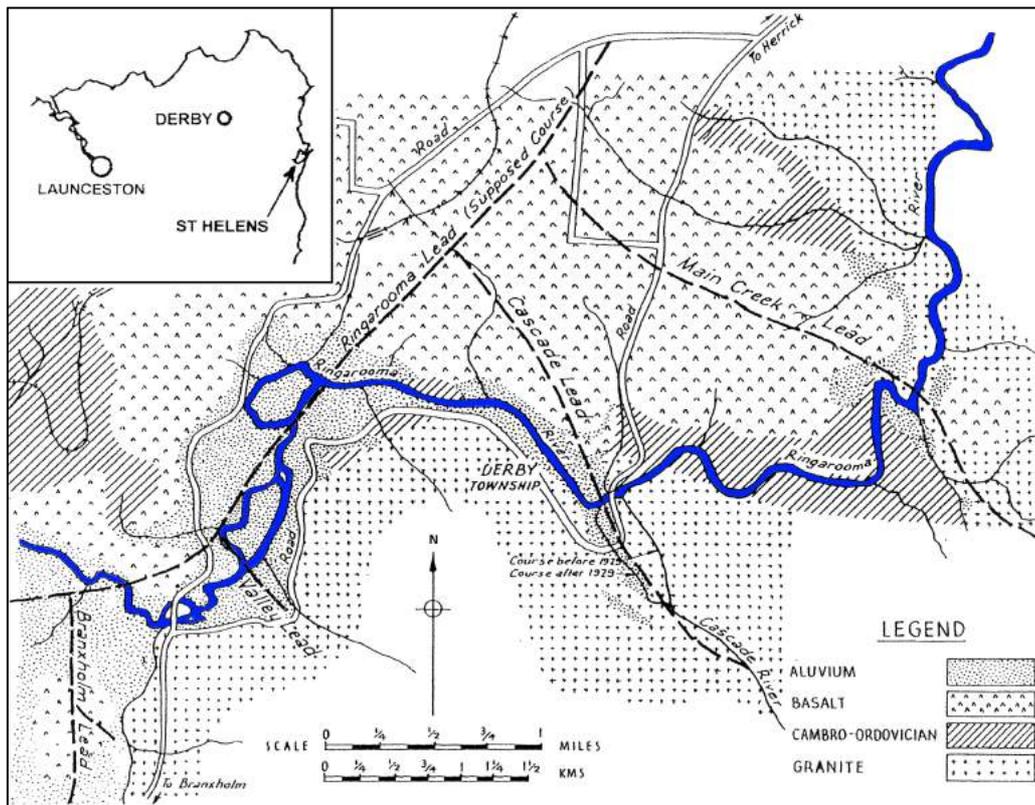
## **Underground mining of alluvial tin leads in Tasmania: a desperate measure**

By KEITH PRESTON

Alluvial tin deposits along the upper section of the Ringarooma River were first mined at Branhholm in mid-1875, instigating extensive prospecting along all associated tributaries.<sup>1</sup> Tin deposits were discovered on Main Creek to the east of Derby by November, inducing brothers Charles & Fred Krushka to register the Black Boy claim on Lease 361.<sup>2</sup> After further deposits were located by the brothers at Brothers' Home gully to the east of the Derby township, Lease 316 was registered in March 1876, this the first exploitation of the extensive deposits within the Cascade Deep Lead (Fig.1).<sup>3</sup>

Mining of the alluvial tin deposits between Branhholm and Derby was initially conducted by ground sluicing from the mid-1870s to early-1880s, then generally by hydraulic sluicing once high level water supply races had been constructed to provide water at elevated pressure.<sup>4</sup> Where the tin leads were cut by the Ringarooma River, the most favourably located leases within the floodplain could be worked simply by excavating steeply-battered faces into the river banks in order to remove the overburden and expose the rich alluvial tin deposits towards the base of the lead. Mining proceeded until the overburden height in the working face became inherently dangerous for the miners; was limited by the reach of sluicing nozzles; or where the upper limit of the overburden batter approached the lease boundary of the adjoining claims. Mining progress could also be curtailed where a lease was traversed by the water supply race of a neighbouring company, as a Supreme Court ruling in April 1884 prevented trespass by undermining a water race when the associated water right was granted as an easement.<sup>5</sup>

For mining companies working leases on elevated terrain without a river frontage, the critical factor governing mine operation was tailings disposal, as any tailrace would need the co-operation of neighbouring leaseholders bordering the river. Mine managers along the Ringarooma River encountered all of the foregoing situations, particularly those working the Cascade Lead. On this field, mining companies were reluctant to co-operate, holding out for additional leverage when contemplating a merger or sale of their lease holdings. In addition, disputes over water rights or lease infringements promoted hostility and belligerence, both on the northern bank of the river between the Triangle and North Brothers Home Tin Mining Companies, and to the south of the river where the Brothers' Home No. 1 and Briseis Tin Mining leases abutted the privately owned lease of the Krushka Brothers.<sup>6</sup> In order to break the deadlock that developed by the mid-1880s, unconventional solutions were adopted including underground mining of alluvial tin leads.

**Figure 1:** Tin leads in the vicinity of Derby.

Source: H.H. Dunkin, 'Sluicing Operations at Briseis Consolidated N.L', *Chemical Engineering and Mining Review*, vol. 38, July 1946, p. 353.

### Cascade Lead geomorphology

During the Tertiary period (6.5-2.6 million years ago) the course of the Ringarooma River lay to the northwest of the current river, with its bed lying some 30-45m below the level of the present floodplain (Fig. 1).<sup>7</sup> Alluvial deposits accumulated in the river valley to an estimated maximum depth of 150m before being covered by basalt flows up to 30m thick. Along the former Cascade River valley the alluvial deposits attained a maximum thickness of some 75m, the rich tin deposits towards the centre of the lead having a maximum width of 120m. The course of the post-volcanic Ringarooma River generally follows the basalt contact with the granite bedrock, flowing southeast towards the Derby township and then swinging northeast to cut the Cascade and Main Creek Leads at approximately 90 degrees. The *gutter* of the Cascade Lead to the south of the Ringarooma River dipped to the northwest at an average grade of 1 in 40 (1.5 degrees) within the Briseis lease holdings.<sup>8</sup> This determined that the tin-rich basal layers of the lead, some 18m thick, were exposed in the southern bank of the river at, or up to 30m below, river level, with depth beneath the northern bank of the river approaching 45m.

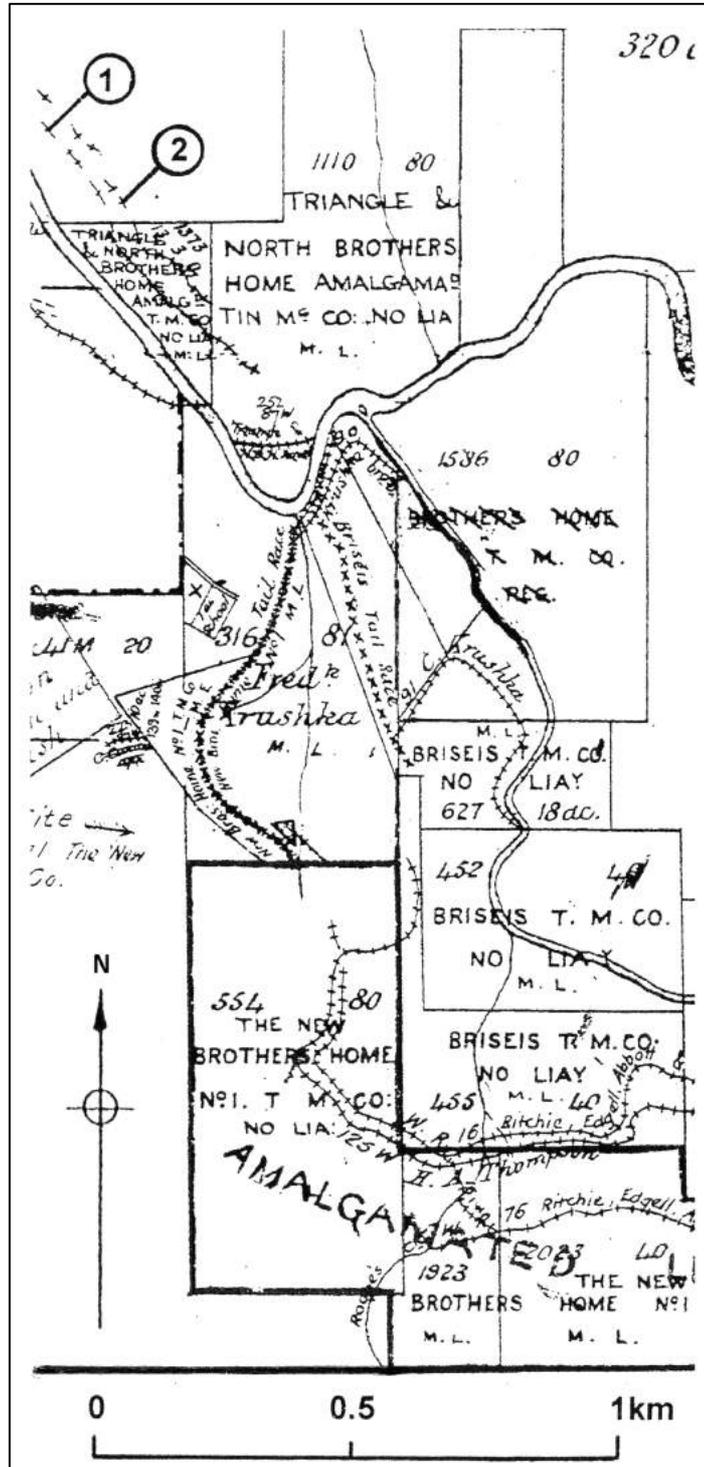
### Underground mining considerations north of the Ringarooma River (1885)

Mining of the Cascade Lead on the northern bank of the Ringarooma River was initially undertaken by the Triangle Tin Mining Company [Triangle Co. hereafter] and North Brothers Home Tin Mining Company Limited [NBH Co. hereafter], between 1882-85

(Fig. 2).<sup>9</sup> A dispute over a water right held by the NBH Co. that crossed the neighbouring Triangle Co. Lease 1373 was resolved in the Supreme Court in favour of the former company during 1884.<sup>10</sup> This ruling prevented the Triangle Co. from undertaking any further working of the tin lead on Section 1373 by hydraulic sluicing as this would have resulted in further undermining and damage to the NBH Co. supply race.<sup>11</sup> As a result, both companies were unable to continue mining economically: the Triangle Co. having no access to a high level headrace without the cooperation of their neighbours, while the NBH Co. were disadvantaged by the Triangle Co. lease encompassing the main gutter of the lead, thus preventing the NBH Co. from undertaking hydraulic sluicing into the river bank.

As a result of delays in establishing a high-level headrace to enable hydraulic sluicing to commence, the *Lease holdings along the Cascade Melbourne* directors of the NBH Co. resolved in February 1885 to approach Mt. Bischoff mine manager H.W.F. 'Ferd' Kayser to undertake a review of mine development options.<sup>12</sup> He was critical of the lack of prospecting following flooding of a tunnel driven from river

**Figure 2:** Lead: Triangle & North Brothers' Home north of the Ringarooma River; Krushka Brothers, Brothers' Home No. 1 & Briseis Cos. to the south. Water Races from Boyd's Creek labelled: (1) Low Level Supply & (2) High Level Supply - see appendix 1.



November 1885 - May 1891.

level the previous year. Comment was also provided on the adoption of underground mining, no doubt prompted by NBH Co. director (and mining engineer) Richard Dunlop Thompson. Kayser was not in favour due to ‘the loose nature of the ground’.<sup>13</sup> A ‘heavy slip from the basaltic formation [capping layer]’ of approximately 2,000t in October that buried the exposed tin deposits forced the directors to act, with Thompson visiting the mine three months later to commence preparations for underground mining.<sup>14</sup>

### **Blocking out methodology**

A method of mining deep gold leads, in which younger basalt layers overlay auriferous alluvial deposits, was developed on the Central Victoria goldfields from the late 1850s, being referred to in Tasmania, as the *Ballarat blocking out method*.<sup>15</sup> Victorian underground mining practice entailed first sinking a vertical shaft to one side of the lead where the bedrock was closest to the surface. After sinking to a depth greater than the anticipated deepest part of the gutter, a drainage tunnel (the *reef drive*) was driven through bedrock beneath the lead gutter. From the reef drive, bores were drilled upwards at frequent intervals into the washdirt in order to de-water the highly-permeable, basal layers. Once drained, short vertical rises were excavated to open out the gutter.<sup>16</sup> Water was raised to the surface by large steam-pumping plants requiring considerable surface infrastructure (and high working expenses). When groundwater pressures had been reduced by lowering the water table, a further tunnel (the *wash drive*) was driven from the shaft at a higher level, along the line of the lead, to intersect the washdirt layers. Cross drives driven perpendicular to this tunnel enabled blocking drives to be established from which panels of washdirt were removed.

In contrast to mining along the Ringarooma River, the sub-basaltic leads were typically not exposed by existing watercourses on the Ballarat, Maryborough and Creswick goldfields. Consequently, the blocking out system was adapted to overcome constraints due to the local geology and de-watering requirements. The ‘Ballarat method’ was first used in Tasmania on the Back Creek goldfield (east of the Tamar estuary) in 1870 by a former Victorian miner Charles H.E. Blachmann, and on a larger scale at the Beaconsfield goldfield in 1878.<sup>17</sup> Its adoption on the Cascade Lead by the NBH Co. for mining alluvial tin was a last-ditch option to overcome their failure to achieve a working agreement with the Triangle Co.. Kayser summed up the challenges:

The main points to consider are to have the main level well under the workings in solid ground, the pump to be able to manage the water, a winding-gear to haul not less than 500 tons in 24 hours, and the necessary timber, which is plentiful, to keep the ground secure, while blocking is carried on from rise to rise, which are connected with the main level.<sup>18</sup>

As a result of the Cascade Lead being intersected by the Ringarooma River, groundwater from the upper (southern) section of the lead drained towards the river due to the northerly inclination of the gutter, while on the northern bank seepage from the river into the mine workings occurred. The upper section of the lead was also subject to recharge from the Cascade River and increased rainwater infiltration due to the reduced

depth of cover. In both instances, de-watering of the alluvial deposits was required to facilitate underground mining, either by means of drainage adits, or by pumping.

### **Underground mining at the North Brothers' Home mine (1886-1887)**

Underground mining commenced in April 1886 when only two shifts could be worked, as 'great difficulty was experienced in getting practical miners as they have to be sent from Victoria and leave almost as fast as they arrive'.<sup>19</sup> A production rate of about 5t tin oxide per week in August was expected to double by the end of year but this failed to materialise, possibly because only limited deposits were located above the water table.<sup>20</sup> Encouraged by a tin grade of 0.4-0.5% oxide, however, a further share issue sought to raise an additional £20,000 from existing shareholders to fund the excavation of a 'water drive' (a *reef drive* in Victoria) below the gutter and to install a shaft with winding and pumping plant, as well as additional tin processing machinery at an estimated cost of £1,750.<sup>21</sup>

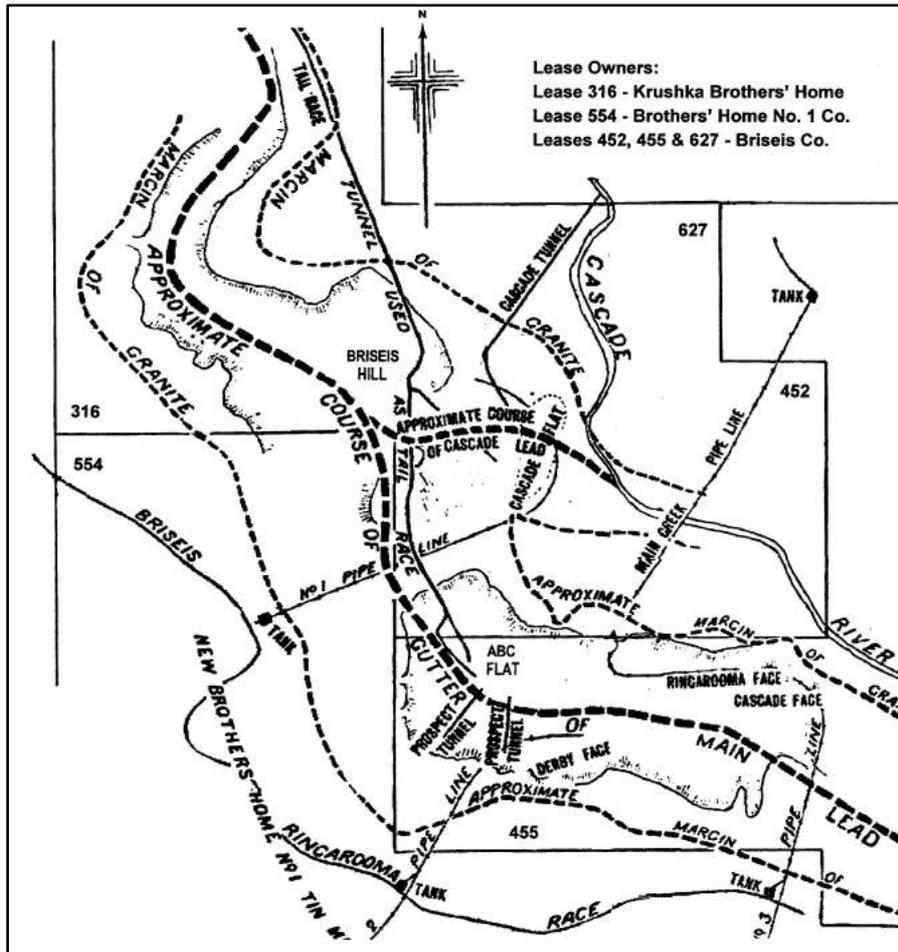
As the water brought to the claim was no longer required for hydraulic sluicing, it could be utilised for power generation to reduce operating costs. Three 'turbines' were reported to have been supplied from Melbourne to power the shaft pumps and hoist. A turbine was purchased in January 1887 from the Simmons Reef Amalgamated Co. at Blackwood, Victoria, for £130 but no details of the others are known.<sup>22</sup> Mine manager Michael J. Griffin also advertised locally for a 15-20ft diameter iron-framed waterwheel to drive the trolleys.<sup>23</sup> As the portal of the washdirt drive was located 'not much above the river level, in case of floods a water-tight door shuts off the tunnel, and a set of 8-inch centrifugal pumps enable them to continue work from the shaft'. A requirement to utilise all available sources of water determined that the mine water was recycled, as the 'centrifugal pump would supply ample water for sluicing with, but for stripping purposes, was totally inadequate'.<sup>24</sup>

Commissioning of the surface infrastructure was completed by early September and a month later the first output of one ton was reported at a disappointing 0.25% grade.<sup>25</sup> A further capital raising of £7,500 was now announced, ten months after the first issue of additional shares, suggesting that a heavy price was being paid for the underground development, especially the increased workforce (up to 100 men) and cost of obtaining timber for roadway support.<sup>26</sup> Reported weekly production through to the end of the year did not exceed some 3t at grades of between 0.27-0.315%.<sup>27</sup> A summer shutdown at the beginning of February 1888 due to a water shortage ended the first underground mining venture. Since the company's inception in November 1880, operating costs totalling some £40,000 had been sourced from shareholders (contributing about £12,000) and all revenue came from ore sales, with no return by way of dividends.<sup>28</sup> Engineer Thompson was voted off the board of directors in February and had withdrawn from all involvement in the mine by mid-1888, having at the end of April been appointed mine manager of the Brothers Home No. 1 Tin Mining Co..<sup>29</sup> The next attempt at economic working of the Cascade Lead by underground mining now moved across the Ringarooma River.

### **Stalemate south of the river (pre-1885)**

Krushka Brothers Lease 316 was the first claim to be worked south of the river, encompassing a section of the Cascade Lead extending beneath Briseis Hill, which formed a 350ft high topographical barrier to surface mining.<sup>30</sup> The lead continued through the northeast corner of the Brothers' Home No. 1 Tin Mining Company [BH1 Co. hereafter] Lease 554, before turning southeast to east through the lease holdings of the Briseis Tin Mining Company [Briseis Co. hereafter] (see Fig. 3).

**Figure 3:** Sketch plan of the Cascade Lead showing the Briseis Main Tail Race Tunnel. Lease numbers added.



Source: *The Argus*, 29 April 1902, p.8.

The Krushka Brothers worked their claim simply by extending working faces into the footslopes of Briseis Hill by hydraulic sluicing, with a height of approximately 200ft attained by August 1889.<sup>31</sup> Slumping of the alluvial deposits and rockfalls from the basalt-capping layer were a continual hazard, hindering overburden stripping and exposure of the gutter. Mining on the neighbouring BH1 Co. Lease 554 was constrained by the close proximity of the Briseis lease boundary but co-operation of the Krushka Brothers was secured in obtaining an easement on a portion of their lease for the disposal of tailings (Fig. 2).<sup>32</sup> The Briseis lease holdings encompassed the uppermost section of the Cascade Lead as it approached the deeply-incised Cascade River and also a substantial lead paralleling the river. Its operations were severely restricted by Briseis Hill, which extended eastwards to the Cascade River, preventing direct access to the

Ringarooma River for tailings disposal. Only limited quantities of tailings could be discharged into the Cascade River as this was utilised for the Krushka Brothers headrace (Fig. 2), with both operations hindered by greatly reduced summer flows.<sup>33</sup>

### **Briseis tailrace: a high risk investment (1885-1890)**

The Briseis Co. moved first to break the impasse by commencing to drive a 1,180ft long tailrace tunnel (referred to as the Main Tail Race Drive) from the bank of the Ringarooma River beneath the workings of the Krushka claim to intersect the deep lead at the eastern boundary of Section 627 (Fig. 2). Work on the substantial 10ft wide by 8ft high tunnel commenced in November 1884 but progress was soon slowed when high strength granite was encountered underlying the deep lead.<sup>34</sup> Tenders were called for the supply of rock boring equipment in December, with installation completed three months later when ‘three experienced Sandhurst [Bendigo] rock-borers [miners]’ were recruited, and the equipment was commissioned at the end of April 1885.<sup>35</sup> Progress was painfully slow as only 8-10ft was driven per week by working two shifts, the tunnel taking 38 months to complete under the direction of mine manager Thomas Bruce and engineer John C. Aiton. Following registration of the Ballarat company in July 1883, the construction cost of £9,234 formed 34% of the total mine development expenditure of £27,148 – an expensive commitment by the largely Victorian shareholders.<sup>36</sup>

During the lengthy construction period, mine plans were revised to take account of additional prospecting, with the upper end of the tunnel being re-positioned beneath the ‘ABC Flat’ at the boundary between Sections 452 & 455 (Fig. 3).<sup>37</sup> This entailed a further 1,000ft of tunnelling through difficult ground formed of poorly-consolidated alluvial deposits, the project stalling for nine months due to heavy groundwater inflows, before contracts were let in stages.<sup>38</sup> Progress continued to be slowed by poor ground conditions towards the end of 1889, when a 24ft section of the tailrace was ‘re-driven ... in heavy running ground’.<sup>39</sup> All underground development was finally completed in March 1890, after a protracted five-year construction period, when washdirt from the nozzles was directed to a 100ft deep dump shaft connecting with the tailrace.<sup>40</sup> A chamber with plan dimensions of 24ft by 40ft was excavated in granite at the head of the tailrace tunnel for the installation of four sluice boxes, a second shaft (the ‘D Shaft’) was required for the water supply pipes.<sup>41</sup> The financial burden of the tailrace tunnel prompted an offer of £25,000 in November 1889 for the Krushka Brothers lease, which was rejected, as four times that amount was rumoured to be the asking price. Eight months later, the sale price was reduced to £62,000, but remained too high even for the considerable financial resources of the Ballarat company.<sup>42</sup>

### **Brothers’ Home No. 1 implement underground mining (1887-1890)**

Progress with underground mining north of the river was being monitored by the BH1 Co. directors through the latter part of 1886 before a contract was let for a drainage drive in January.<sup>43</sup> Further assistance of the Krushka Brothers was essential for the proposed development plans as the drainage tunnels would discharge on their side of the lease boundary and an additional easement within their lease was required to site a shaft and

associated machinery for hoisting.<sup>44</sup> Engineer Thompson had placed orders for machinery in March, the Atlas Company of Engineers (Carlton, Melbourne) to supply a:

double turbine [two pelton wheels], which is to be employed in working the winding gear, one of its special advantages being that it will do away with a quantity of gearing. The water will be turned into one turbine for hoisting, and into the other for reversing.<sup>45</sup>

A further pelton wheel was supplied to drive tromeels and jiggers that were produced by W.H. Knight's Launceston foundry.<sup>46</sup> Work on the wash drive commenced in May 1887, 'it is constructed to work with horses, being 7ft. 6in. high, 6ft. 6in. wide at the bottom, and 4ft. 6in. wide at top, all within the timbers' – thereby following established Victorian practices.<sup>47</sup> By mid-June the wash drive had advanced 244ft and the shaft was down 40ft, 'the ground has been very troublesome, the rock very hard and the pug [clay] overlying it swelling and so heavy that it is breaking some of the shaft timber'. A week later as conditions worsened, Thompson 'had to provide oilskin coats for the men in the shaft'.<sup>48</sup> Progress continued to be slowed but by November the wash drive had been driven 538ft and water (drainage) drives completed. The following month all was ready for blocking out to commence.<sup>49</sup> A reduced output for the half-year to December 1887 of 40t (average 3.25t per week) at an average grade of 0.5% was reportedly 'not up to Mr Thompson's estimate'. Six months later at the shareholders' meeting, despite an 80% increase in tin production, the mine continued to operate at a loss. Thompson in his defence explained 'the want of water prevented us raising a larger quantity of tin while the price was high, and now the water is plentiful we have great trouble in getting sufficient miners used to this drift mining to get the mine worked up to its full capacity'.<sup>50</sup>

An improved method of blocking out was devised by Thompson in 1888 by driving an intermediate level enabling an increased quantity of wash to be mined at reduced cost, but as a result of survey errors the drive was 'not kept within the line of the easement granted by the Government through Messrs Krushka's property ... [requiring] construction of a new drive at heavy cost [£1,500], as a portion of it was through hard rock'.<sup>51</sup> Thompson resigned following the shareholders meeting in July 1889, before he could be credited for a further 245% increase in production resulting in an even larger 285% increase in revenue due to a rising tin price.<sup>52</sup>

As a result of water shortages the previous year, a steam powered winding engine was installed in March 1889, enabling a weekly output of some 8-9.5t to continue until mid-July when a roof fall buried a miner, who was fortunately rescued uninjured.<sup>53</sup> Deteriorating ground conditions and increased groundwater inflows now prevented rich deposits towards the base of the gutter from being mined, leading to 100 men being laid off a month later.<sup>54</sup> With the bank overdraft rising and shareholders becoming restless, a company re-structure led to the New Brothers' Home No. 1 Tin Mining Co. No Liability [hereafter NBH1 Co.] being formed a year later with a capitalisation of £60,000<sup>55</sup> (See Appendix 2 for a summary of company changes). The new directors favoured abandoning blocking out but approaches to the Krushka Brothers for 'conjoint working' by surface mining were rebuffed.<sup>56</sup> Another mine manager, Leonard Slade was recruited

from the nearby Ringarooma Valley mine to pursue underground mining but further groundwater incursions in July and August 1890 prevented deeper levels being established. Conditions remained unchanged six months later, ‘the pressure in the hill is very great, gradually crumbling the great timber supports to the tunnels like rotten wood’.<sup>57</sup>

**Briseis vs New Brothers’ Home No. 1 boundary dispute: ‘a right to lateral support’ (1891)**

Reduced groundwater inflows during the last quarter of 1890 enabled the NBH1 Co. to proceed with blocking out adjacent to the Briseis lease boundary.<sup>58</sup> A decline driven along the Krushka boundary provided access to the lower tin deposits (the No. 3 Level), enabling roadways to be driven in October-November both along, and parallel to the Briseis boundary. Crosscuts were established to enable panels, with approximate dimensions of 50ft by 60ft, to be worked by blocking out.<sup>59</sup> Immediately to the east of the boundary, the Briseis Co. had established its Main Tail Race Drive and associated prospecting headings at a cost exceeding £15,000 (Fig. 4).<sup>60</sup>

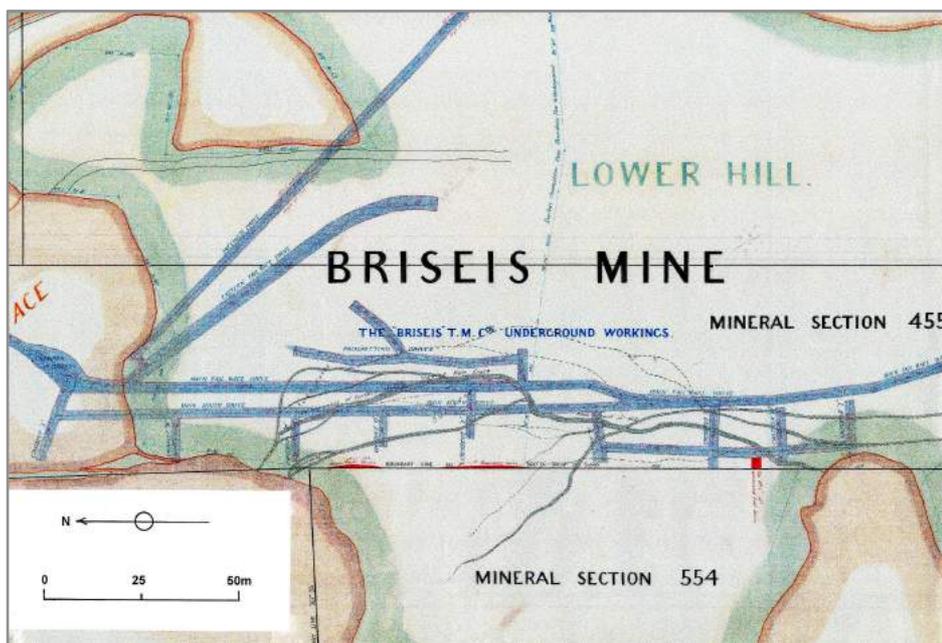
The first indications of ground movement resulting from washdirt extraction were apparent by mid-1890 when NBH1 mine manager Slade undertook an inspection of surface cracks on the Briseis claim with his counterpart John Aiton.<sup>61</sup> This was likely to have resulted from above average rainfall in June-July that enabled the Briseis Co. to operate three 4 inch giant nozzles at full pressure from mid-June.<sup>62</sup> Infiltration of additional surface water within the alluvial deposits would have led to increased pore water pressures developing below the water table and an associated reduction of shear strength, leading to subsidence above the worked out panels.<sup>63</sup> Further displacement on 28-30th November led to cracking extending for some 700ft along the lease boundary (see Fig.4). As the full overburden load was bearing on the roadway support, 19 timber sets along the Briseis Tail Race Drive were sufficiently damaged to need replacing.<sup>64</sup> Fearing on-going damage to critical infrastructure, an interim injunction was obtained in the Supreme Court by the Briseis Co. on the 21<sup>st</sup> December, preventing further blocking out abutting the lease boundary.<sup>65</sup>

With its mining operations paralysed by the court injunction, the NBH1 Co. had no option but to apply for the injunction to be dissolved, their Melbourne counsel claiming that the lease conveyed the right to mine up to the boundary. The full bench of the Supreme Court was now required to grapple with the complexity of mine subsidence, in an era when an understanding of practically all aspects of soil and rock mechanics was quite rudimentary.<sup>66</sup> In his lengthy summary, the Chief Justice, quoted from the affidavits of Briseis manager Aiton and Mines Inspector Harrison, who endorsed Aiton’s opinion:

... it would be impracticable now, owing to the broken character of the ground in the defendants’ [NBH1 Co.] mine caused by the system of working ... to substitute any artificial lateral support for the plaintiffs’ mine in the place of the natural support originally afforded to it by the ground of the defendants.<sup>67</sup>

Of the contention put forward by the NBH1 Co. legal counsel, that infiltration of water from hydraulic sluicing on the Briseis claim had contributed to the instability, the Chief Justice found the evidence ‘contradictory’, again relying on the opinion of Harrison ‘that the workings in the defendants mine were likely to cause further damage’. The NBH1 Co. application was therefore, refused. An appeal was heard in November 1891, by which time the mine had been shutdown for eleven months.<sup>68</sup> Chief Justice Dobson’s ruling was that the Briseis Co. was entitled to a ‘perpetual injunction’ restraining the NBH1 Co. from blocking out ‘so near to the boundary ... as to cause any of the drift to run in from the plaintiffs’ mine ... depriving the mine of its natural lateral support’.<sup>69</sup> The ramifications of this ruling were of considerable importance for future mining, as ‘Between adjoining mine owners, there is a right to lateral support, not only of the surface but of the soil beneath ...’.<sup>70</sup>

**Figure 4:** Plan of Cascade Lead showing development of surface subsidence cracks on Briseis Lease 455 adjoining Brothers’ Home No. 1 Lease 554 with underground workings of the Briseis Co. superimposed. The sluice box chamber at the head of the tailrace tunnel at left centre. Granite margin coloured red, alluvial deposits green.



Source: Mineral Resources Tasmania, Drawing No. 0349-016, December 1890.

#### **New Brothers’ Home No. 1: renewed underground mining (1892-1894)**

A petition for leave to appeal the Supreme Court ruling to the London Privy Council three months later was deferred, after which the NBH1 Co. appears to have adopted a more conciliatory approach. In September the incline drive was extended to enable a layer of washdirt (the No. 4 Level) to be mined. A drainage drive to the open face on the Krushka Brothers claim was also required to counter increased groundwater inflows.<sup>71</sup> A plan of the No. 4 Level workings produced in March 1893, reveals that the mine headings encroached no closer than 80ft to the Briseis boundary, thereby maintaining a *boundary pillar* to provide the lateral support demanded by the Supreme Court.<sup>72</sup> A brief

period of profitable working during the second half of the year enabled two small dividends to be paid, but a falling tin price forced underground mining to be abandoned by mid-1894.<sup>73</sup> With all mining options exhausted, an agreement was finalised in October for the Krushka Brothers to mine along the common boundary, arbitrators determining the value of tin removed from the NBH1 Co. lease.<sup>74</sup> The deadlock preventing continued surface mining was finally lifted.

### **Underground mining resumed north of the river (1890-1893)**

Amalgamation of the Triangle Co. and NBH Co. proceeded in February 1889 providing for the first time, both access to the water supply race and the ability to work the gutter of the lead as it dipped below the level of the Ringarooma River.<sup>75</sup> The intention of the Melbourne directors was flagged by the appointment of mine manager James ‘Hydraulic Brown’, and confirmed by the overhaul of the water race and removal of rails from the underground roadways.<sup>76</sup> The water race was operational in May and sluicing of overburden using two nozzles proceeded the following month to push the face back 100ft from the limit of the old workings.<sup>77</sup> This would entail the deviation of the supply race beyond the new batter face but no details were reported. As the tin deposits to be worked lay close to, or below, river level, an application for a 20 sluice-head water right (WR 252-87W – see Fig. 2) from the Ringarooma River was lodged in May to enable the tailings to be flushed downstream.<sup>78</sup> However, a revision of the mining methodology was required five months later, when the Briseis Co. objected to the water race from the Ringarooma River ‘as the proposed diversion will so diminish the water in the river, as to deprive it of its scouring powers’ leading to the accumulation of tailings. This prompted the arrival of directors Alfred Shaw & Alexander B. Bruford (a surveyor) in Tasmania to make preparations for renewed underground mining; to attempt a resolution of a dispute with landowners along the headrace, and to introduce tribute working.<sup>79</sup> An incline drive (1 in 12 grade) was underway the following August to raise tin by a horse tramway in order to provide the required fall for the tailrace as it entered the river (Fig.5).<sup>80</sup>

Centrifugal pumps were retained for mine de-watering, but were now steam-driven (Fig. 6).<sup>81</sup> As this was inadequate for controlling inflows, the tributers soon abandoned their contract, leaving the company to install additional steam powered pumping and winding equipment. Only a limited supply of water was now obtained from the final ‘half-mile of head race which will only give water when rain falls’.<sup>82</sup>

Work resumed briefly in mid-1891 but was again halted as the 8 inch Cornish lift pumps were inadequate, larger 12 inch pumps being installed eight months later when they raised very near enough water for one sluice head’.<sup>83</sup> Now the waterwheel was no longer required for pumping, it was adapted for hoisting from the workings at the southern end of the lease (Fig. 6).<sup>84</sup> Underground mining was pursued throughout 1892-93, with a peak production of 3-4t per week attained in the final quarter of 1892.

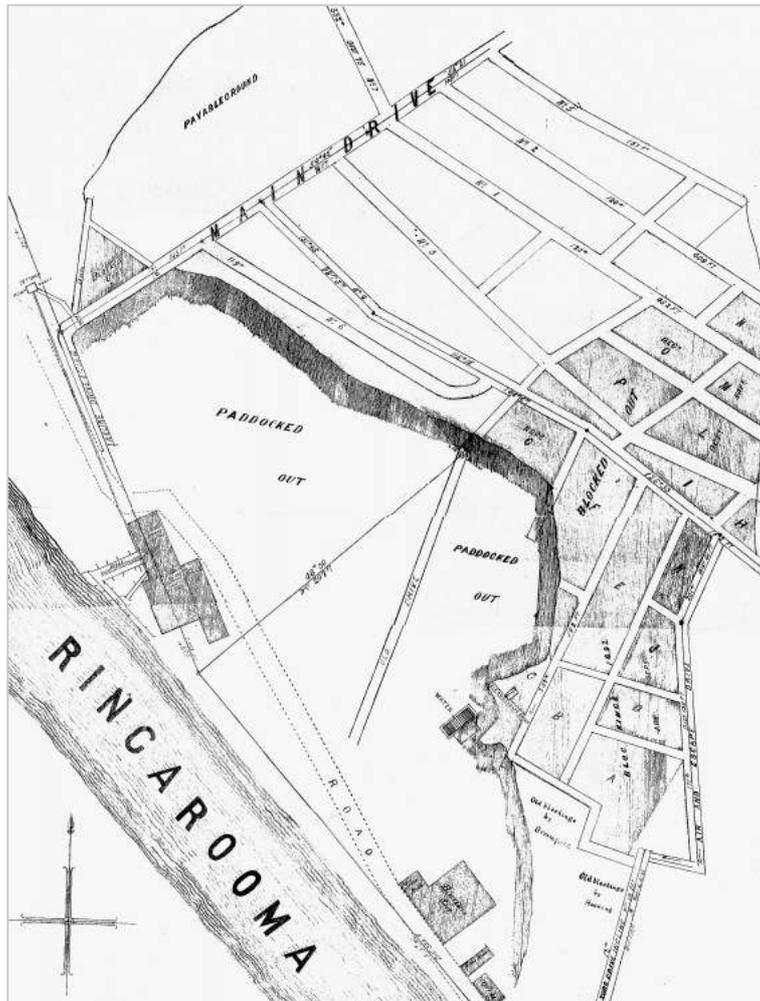
**Figure 5:** View looking in a north-easterly direction towards the Triangle Lease 1373 with the tailrace centre and engine shed housing a centrifugal pump to the left. Disused water race (WR 124W) in the right foreground used for flushing tailings downstream. Basalt capping layer evident overlying the Cascade Lead.



Source: Mineral Resources Tasmania, Photo No. 0009-39, undated but probably early to mid-1902.

A continuation of underground mining in mid-1893 north of the boundary of the adjoining Beswick estate was facilitated by an agreement made ten years earlier when a flotation of the Beswick Freehold Tin Mining Co. was attempted in Melbourne.<sup>85</sup>

**Figure 6:** *Plan of Triangle & North Brothers' Home surface infrastructure with underground blocking out workings superimposed.*



Source: Mineral Resources Tasmania, Drawing No. 0271-002, undated but probably December 1892.

Increased groundwater inflows overwhelmed the pumps in August 1893, leading to mining being curtailed at the end of September, and the property advertised for disposal a month later.<sup>86</sup> This marked the end of underground extraction of alluvial tin north of the river, three ventures being unable to establish a viable mine. Two further attempts at working the amalgamated leases by hydraulic sluicing proceeded, utilising alternative sources of water and demonstrating the resourcefulness of mine managers.

#### **Brothers' Home Extended TM Co: a bonanza for a few (1896-1899)**

A syndicate of largely local miners formed the Brothers' Home Extended Tin Mining Co. in October 1895 with a capitalisation of only £250 in 25s shares.<sup>87</sup> Their first priority was to take up the water rights to the low and high-level races of the former

Triangle & NBH Amalgamated Co. that had been shown by previous operators to be deficient in providing the intended flow rates (Appendix 1).<sup>88</sup> Despite the inauspicious history of failed ventures, the group of canny miners running a low cost operation produced two small dividends before the 1896 spring rains failed, 'the first of the kind ever paid by this mine'.<sup>89</sup> Mining resumed the following winter when three further dividends were declared, but a water shortage was limiting output.<sup>90</sup>

A new water source was now proposed using a 4-mile long headrace from Main Creek to the southeast of the mine that required crossing of the Ringarooma River (Fig.7). An application for a 10 sluice-head water right was lodged in December 1897 and a route surveyed by Don Fraser three months later. A nine-month construction period suggests that the syndicate members provided much of the labour, limiting the cost to £1,000, despite a 1,200ft long syphon (by a 16in diameter pipeline) required to span the deeply incised Ringarooma River.<sup>91</sup> A steady output followed, rising from 12t in the last quarter of 1897 to 16t for the equivalent period of 1899. Dividends also increased to 35 shillings & 40 shillings in September-October 1898 due to a resurgence in the tin price.<sup>92</sup> The claim having 'paid many pounds per share in dividends' attracted the attention of Scottish mining engineer T.H. Clouston, who promptly floated a company on his return to Edinburgh.<sup>93</sup>

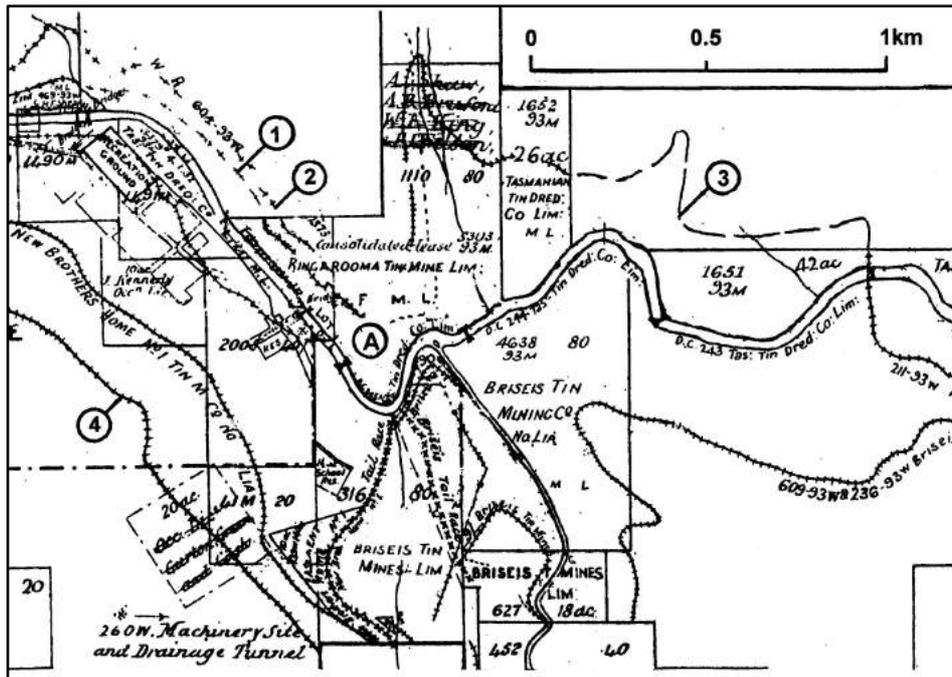
### **Ringarooma Tin Mines Ltd: a costly pumped water supply system implemented (1901-1903)**

Clouston was appointed general manager of the Ringarooma Tin Mines Ltd, the Brothers' Home Extended syndicate receiving £14,000 cash and 8,000 shares for their opportune venture. As the purchase price accounted for 44% of the £50,000 capitalisation, the available working capital was reduced to only £28,000. Engineer George Davidson was engaged in June 1900 to oversee the installation of a steam pumping plant to provide a reliable supply of high pressure water from the Ringarooma River for hydraulic sluicing.<sup>94</sup> No expense was spared in obtaining four compound duplex pumps from J.H. Carruthers & Co. (Glasgow) to be supplied by four (with one spare) Babcock & Wilcox water tube boilers, all housed in a substantial 40ft by 108ft engine house.<sup>95</sup> The Main Creek water right was retained to provide clean water for the boilers. A year later the first pump was trialled, enabling overburden stripping to commence but the supply of firewood for the boilers was soon creating problems for haulage contractors.<sup>96</sup> A further year of unproductive work was required to expose the gutter and install an American hydraulic elevator to raise the washdirt 50-60ft.<sup>97</sup>

The pumping plant supplied an average of 150,000 gallons per hour (equating to 16.5 sluice-heads) for overburden removal at a cost of 10.7d per sluice-head, equivalent to 62% of its design capability. As the supply of firewood continued to retard the rate of overburden removal, a tramway was constructed 'into a forest of timber' but any benefit went unreported.<sup>98</sup> Mining was finally underway in September 1902, with an average monthly tin output of 5.7t (Table 1) maintained until mining ceased twelve months later. The cost of fuel, cited as exceeding £300 per month, was the principle reason for closure.<sup>99</sup>

An alternative water supply scheme was considered, for which ‘a number of men are out surveying water routes; also a big dam site in the vicinity of the main creek’. Clouston returned to Scotland in November 1903 to attempt to raise additional capital for a suction dredging plant.<sup>100</sup> This was unsuccessful and he returned nine months later, merely to oversee the disposal of the leases and plant.<sup>101</sup>

**Figure 7:** Water supply races from Boyd’s Creek- labelled (1) & (2); from Main Creek (3) and the high-level race from the Ringarooma River (4) to the consolidated lease of Ringarooma Tin Mines Ltd; with bridge crossing of the Ringarooma River at Point A.



Source: Mineral Resources Tasmania, Mineral Chart 149c, January 1891 - April 1902.

**Briseis Tin Mines Ltd: acquisition of neighbouring properties (1900-1907)**

The Ringarooma Tin Mines property was acquired by Briseis Tin Mines Ltd in 1907 for £5,000 together with a 21-year lease of the adjoining Beswick Freehold land, a bargain when compared with the price tag of £35,000 paid for the Krushka Brothers lease seven years earlier.<sup>102</sup> Renewed overburden removal commenced during the last quarter of 1907 following the construction of a 30inch diameter steel pipe column from their main headrace off the Ringarooma & Maurice Rivers to the southwest, conveyed across the Ringarooma River along a substantial 300ft long timber bridge (Fig. 7).<sup>103</sup> A plentiful water supply was finally available north of the Ringarooma River – an achievement that had eluded all previous mine operators over a 20-year period. With a pressure head of some 300ft, approximately 46 sluice-heads could be discharged through a 4inch diameter nozzle, about twice that supplied by the former steam pumping plant of Ringarooma Tin Mines Ltd, demonstrating the considerable saving in operating costs provided by a gravitational water supply system.<sup>104</sup>

**Table 1:** Summary of Cascade Lead Production pre-1900

Company	Date	Tin Oxide (tonnes)		Mining Method & Process
		Total <sup>(1)</sup>	Monthly Average	
<b>NORTH BANK OF RINGAROOMA RIVER</b>				
Triangle + North Brothers' Home Cos.	Jul 1883 - Dec 1886	640	15	Opencut – hydraulic sluicing
	Jul 1890 – Nov 1890	c.305	c.11.5	Underground - blocking out
	Jan 1892 - Sep 1893			
Brothers' Home Extended	Aug 1898 – Feb 1900	62	3.6	Opencut – hydraulic sluicing
Ringarooma Tin Mines Ltd	Sep 1902 - Aug 1903 <sup>(2)</sup>	69	5.7	Opencut – hydraulic sluicing
<b>SOUTH BANK OF RINGAROOMA RIVER</b>				
Krushka Brothers' Home	1876 - Jul 1883	?	?	Opencut – hydraulic sluicing
	Jul 1883 - Mar 1899	3,930	20	Opencut – hydraulic sluicing
Brothers' Home No. 1	Jul 1883 - Dec 1887	281	5.1	Opencut – hydraulic sluicing
	Sep 1888 - Jul 1889	c.274	c.27	Underground - blocking out
	Apr 1892 - Jul 1894	332	11.7	
	Jul 1894 - Dec 1899	>77	?	Opencut – hydraulic sluicing
Briseis Tin Mining Co.	Mar 1885 - Oct 1894	511	3.4	Opencut – hydraulic sluicing
	Oct 1894 - Dec 1899	925	14.7	Opencut – hydraulic sluicing
<b>TOTAL</b>	(to Dec 1899)	>7,337		

Notes:

(1) Sources: 'The Progress of the Mineral Industry of Tasmania', MININD1894 to MININD1899-4, MRT; 'Report on the alluvial tin mines at Derby', OS141, MRT.

(2) Production for Ringarooma Tin Mines Ltd added to assist comparison.

## Conclusion

Mining of deep lead alluvial tin deposits within the Ringarooma basin was conducted largely by gravity-fed hydraulic sluicing using water supplied from long headraces. Economic working of the Cascade Lead to the east of Derby was inhibited during the 1880s by a number of factors, principally the depth of the tin deposits requiring high stripping ratios and intransigent mine owners who were unwilling to co-operate in overcoming the constraints imposed by unfavourable geomorphology, limited water supply availability, and the problems of tailings disposal. Disputes over water rights in the mid-1880s between four of the five mining companies had to be resolved in the Supreme Court, placing additional limitations on mining operations.

The working of leases on both sides of the Ringarooma River was deadlocked by 1885, forcing mine management to implement unconventional mining practices. Underground mining of alluvial tin deposits in the Ringarooma basin was introduced by Victorian mining engineer, Richard D. Thompson, by adopting practices developed on the central Victorian goldfields from the 1850s for mining gold from alluvial deep leads. Similar geomorphological characteristics were shared with the Ringarooma Valley deep leads: a thick sequence of poorly consolidated alluvial deposits, generally of high permeability, buried beneath surface outcrops of variably-weathered basalt. Measures

for draining the tin-bearing, basal layers of the deep lead had to be implemented before a network of underground ‘roadways’ could be established. Access drives required extensive stabilisation by means of timber support frames and close boarding. Underground mining was pursued for nine years between 1886 and 1894 but was ultimately found to be uneconomic due to the increased workforce required, the cost of obtaining the prodigious quantities of timber for stabilisation of the workings, and a falling tin price. Two of the mining companies were also subjected to the high running costs of steam-powered plant for pumping or hoisting.

Company amalgamation north of the Ringarooma River in 1889 partly addressed the restrictions on mining but operations continued to be hindered by inadequate water supply for sluicing. Alternative water sources, from Main Creek (a tributary of the Ringarooma River) and by steam pumping, were implemented but found to be deficient in the former case and uneconomic in the latter. To the south of the river, underground mining led to a dispute over the effects of mine subsidence, requiring a landmark ruling in the Supreme Court to ensure ‘a right to lateral support’. The key to unlocking the extensive tin deposits beneath Briseis Hill and the Ringarooma floodplain was the formation in 1899 of the well-financed Briseis Tin Mines Ltd in London, enabling the neighbouring operations to be acquired by 1907 and overburden stripping on a large scale to proceed. Economic working was finally achieved at the turn of the 20<sup>th</sup> century following the provision of large diameter pipelines from newly-constructed supply races to the south of the river.

Estimated tin oxide production from the Cascade Lead up to the end of the 19<sup>th</sup> century of 9,600t was obtained largely by open cut mining of the river banks, particularly by the Krushka Brothers, whose foresight in locating their lease facilitated highly profitable working (Table 1).<sup>105</sup> Although the average monthly tin output obtained by underground mining compares favourably with that from opencut working, the output from the former accounted for less than nine percent of the total output to December 1899. With hindsight, collaboration by the mine operators would have benefitted all parties by significantly reducing both development and operating costs, enabling increased profits to be generated before a period of high tin prices ended during the mid-1890s depression.

## Acknowledgements

The assistance of AMHA member Greg Dickens with drawing searches and the supply of plan copies by Mineral Resources Tasmania [MRT] is gratefully acknowledged. Two anonymous reviewers provided critical comment and one prepared a flow chart, an amended version being included as Appendix 2.

## Units

Imperial measurements quoted in this article are based on historical sources.

These dimensions may be converted to metric equivalents by the following ratios:

1 in (inch) = 25.4 mm, ft (feet) = 0.3048 m, 1 ml (mile) = 1.6 km

1 ton (long) = 2,240 lbs (pounds) = 1.016 t (tonnes) = 1,016 kg

1 ac (acre) = 0.405 ha (hectare) = 4,047 m<sup>2</sup>

1 gallon = 4.55 l (litres), 1 ML (megalitre) = 219,780 gallons

1 sluice-head (Tasmanian) = 24 cubic feet/min = 149.5 gallons/min = 41,000 L/hour (approx. 1 ML/day)

## Pre-decimal currency

£1 (pound) = 20s (shillings), 1s (shilling) = 12d (pence).

At decimal conversion on 14th February 1966 - £1 (pound) = AU\$2 = 200c (cents).

This does not take into account historical inflation and other factors.

## Appendix 1: Summary of Water Rights to Leases 1110 & 1373

Ref. No. <sup>(1)</sup>	Source	WR No. <sup>(2)</sup>	Lease Date	Sluice Heads <sup>(3)</sup>	Approx. Length	Applicant
<b>Tailings Race</b>						
	into Ringarooma R	124W	1 Feb 1885	50	2,360 m	North Brothers' Home
<b>Western Supply: Low Level</b>						
①	Boyd's Creek	42	1 Sep 1883	10	3,940 m	North Brothers' Home
		20-93W	1 Oct 1894	2		Brothers' Home Extd
		582-93W	1 Jun 1901	3		Ringarooma T.M. Ltd
<b>Western Supply: High Level</b>						
②	Legerwood Rivulet	61	1 Jul 1883	40	?	North Brothers' Home
	Pearce's Creek <sup>(4)</sup>	93-93W	1 Apr 1896	5	16.1 km	Brothers' Home Extd
	French's Creek	93-93W	1 Apr 1896	5	31.4 km	Brothers' Home Extd
	Boyd's Creek	119W	1 Oct 1884	6	3,700 m	North Brothers' Home
	604-93W	1 Mar 1901	2	Ringarooma T.M. Ltd		
<b>Eastern Supply</b>						
③	Main Creek	38-93W	1 Mar 1895	10	6,430 m	Brothers' Home Extd
		211-93W	1 Aug 1898	+1		Ringarooma T.M. Ltd
<b>Southern Supply</b>						
④	Ringarooma Race	756W	1 Jun 1908	c.40	1,035 m	Briseis Tin & General Mining Co. Ltd

Notes:

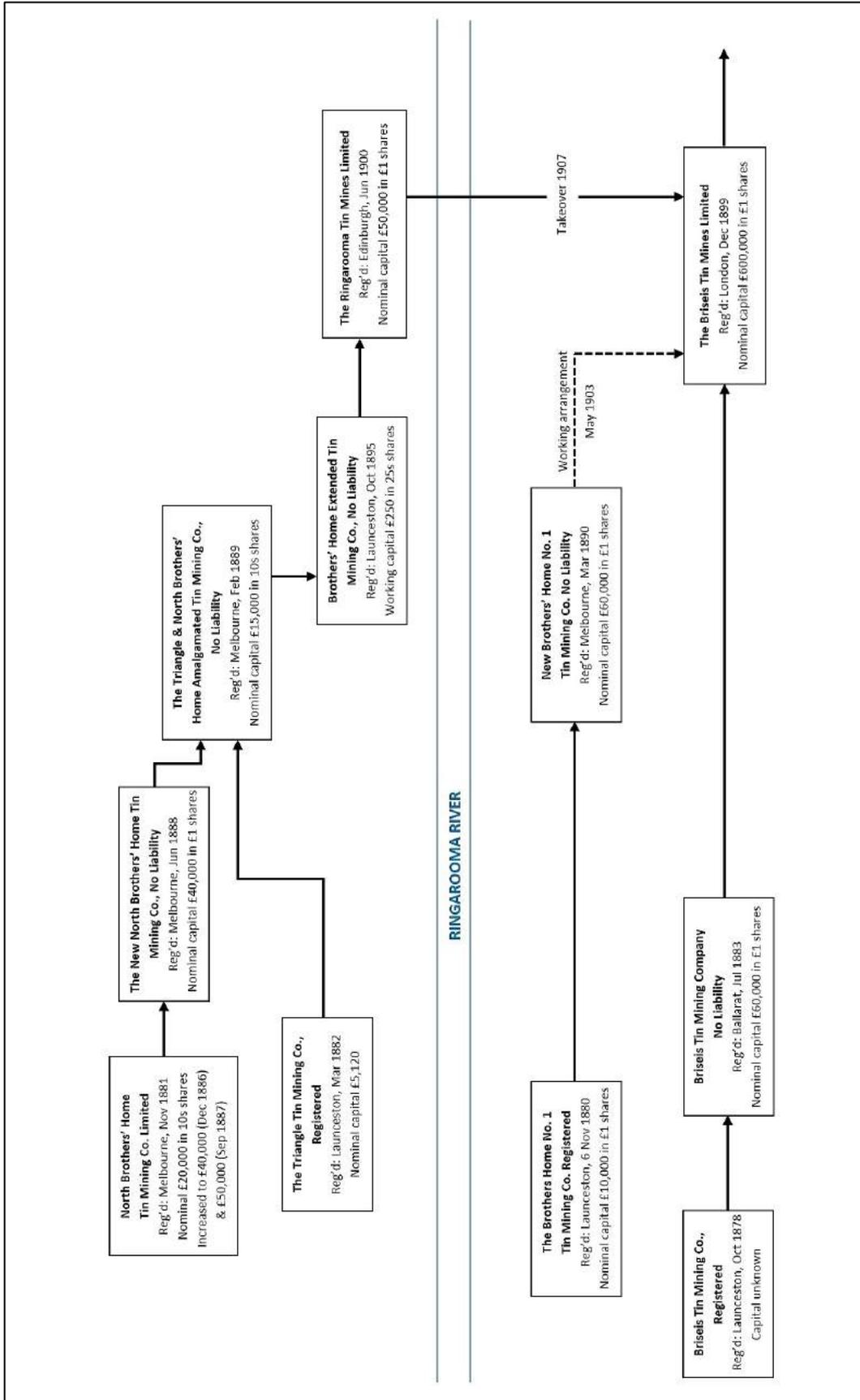
(1) Reference labels as shown in Figures 2 & 7.

(2) Water Rights compiled from the Mines Department Register of the issue of mineral leases (TAHO MIN120) and Register of water right applications (TAHO MIN90).

(3) Maximum Diversion Rate measured in Sluice Heads, where 1 SH (Tasmanian) = 24 cubic feet/min, equivalent to 0.68 m<sup>3</sup>/min or 41,000 L/hr.

(4) Now known as Fenckers Creek.

## Appendix 2: Summary of Mining Companies involved in Deep Lead Alluvial Tin Mining at Derby



Endnotes

<sup>1</sup> K. Preston, 'Tailings disposal at the Arba Mine: a legislative nightmare', *Journal of Australasian Mining History*, vol. 14, October 2016, p. 151.

<sup>2</sup> *Launceston Examiner*, 11 November 1875, p. 3; *ibid.*, 29 June 1876, p. 2; see J. Beswick, *Brothers' Home – the Story of Derby, Tasmania*, 2003, pp. 10-14 for further details of the Krushka brothers.

<sup>3</sup> *Ibid.*, 29 June 1876, p. 2; 'Register of the issue of mineral leases', Lease 316 dated 1<sup>st</sup> November 1876, MIN120/1/1, *Tasmanian Archives & Heritage Office* [hereafter *TAHO*].

<sup>4</sup> *Ibid.*, 28 August 1878 p. 3 – ground sluicing underway at the Briseis mine; *ibid.*, 27 May 1882 p. 3 – ground sluicing introduced on the Krushka Brothers lease; *Examiner*, 4 February 1928, p. 7 – for a detailed account of the working methods on Krushka's lease; *The Mercury*, 10 July 1882 – mining engineer John Lewis reported on the adoption of hydraulic sluicing at The Brothers' Home No. 1 mine.

<sup>5</sup> K. Preston, 'Development of Tasmanian water right legislation 1877-1885: a tortuous process', *Journal of Australasian Mining History*, vol. 15, October 2017, pp. 128-29.

<sup>6</sup> *Ibid.*, pp. 126-28 for a dispute over water rights between the Triangle Co. & NBH Co; *ibid.*, pp. 130-32 for a dispute between the BH1 Co. & Briseis Co.

<sup>7</sup> H.H. Dunkin, 'Sluicing Operations at Briseis Consolidated N.L', *Chemical Engineering and Mining Review*, vol. 38, July 1946, pp. 352-53.

<sup>8</sup> R. Brough Smyth, *The Gold Field and Mineral Districts of Victoria*, Government Printer, 1869, p. 612: gutter – the lowest portion of a lead, filled with auriferous drift, or washdirt.

<sup>9</sup> 'Register of the issue of mineral leases', MIN120/1/2: Lease 1110 transferred to NBH Co., 1 Nov 1881; Lease 1373 transferred to Triangle Co., 1 May 1882, *TAHO*.

<sup>10</sup> MIN120/1/1: WR 42 lease granted 1 September 1883, *TAHO*; *Launceston Examiner*, 19 September, 1884, p. 3 – appeal abandoned by the Triangle Co.

<sup>11</sup> See *Journal of Australasian Mining History*, vol. 15, pp. 126-29 for details of the dispute.

<sup>12</sup> *Ibid.*, p. 129 for details of the delayed headrace construction.

<sup>13</sup> *The Argus*, 3 February 1885, p. 7; *The Mercury*, 4 May 1885, p. 3.

<sup>14</sup> *The Mercury*, 2 October 1885, p. 3; *The Argus*, 30 January 1886, p. 10.

<sup>15</sup> S. Hunter, 'The Deep Leads of Victoria', *Memoirs of the Geological Survey of Victoria*, No. 7, Department of Mines, 1909, pp. 15-20: a modified method was adopted on the Chiltern and Rutherglen goldfields, referred to as the 'Chiltern method', where the overlying basalt layers were absent.

<sup>16</sup> Smyth, p. 619: *reef drive* – 'a drive cut or constructed entirely through the bed-rock'; p. 625: *washdirt* – 'the auriferous gravel, sand, clay or cement in which the greatest proportion of gold is found'.

<sup>17</sup> *Cornwall Chronicle*, 13 July 1870, p. 3; *Launceston Examiner*, 11 March 1878, p. 2.

<sup>18</sup> H.W.F. Kayser, 'Tasmania & its Mineral Wealth', *Australian Mining Standard*, 1 July 1898, p. 40.

<sup>19</sup> *Launceston Examiner*, 9 April 1886, p. 3; *ibid.*, 5 August 1886, p. 3.

<sup>20</sup> *The Argus*, 6 December 1886, p. 11 – 6.1t output at 0.56% oxide; *The Mercury*, 22 December 1886, p. 2 – 5.1t at 0.40% oxide.

<sup>21</sup> *The Mercury*, 9 December 1886, p. 3; *The Argus*, 8 March 1887, p. 9 – all shares taken up raising up to £17,000 on the initial call; *Launceston Examiner*, 14 January 1887, p. 3.

<sup>22</sup> *Bacchus Marsh Express*, 22 January 1887, p. 3; *Launceston Examiner*, 28 June 1887, p. 3; *Daily Telegraph*, 20 December 1887, p. 3; *Bacchus Marsh Express*, 22 July 1882, p. 3 – description of the turbine indicates an inward flow vertical axis reaction turbine supplied and installed by the Atlas Foundry (Melbourne); *Ballarat Star*, 10 December 1881 p. 4 – turbine ordered from New York.

<sup>23</sup> *Ibid.*, 23 February 1887, p. 1; *ibid.*, 2 September 1887, p. 2; *ibid.*, 10 September 1888, p. 2 – Griffin appointed Manager of the Mount Cameron Water Race Board; *ibid.*, 1 February 1898, p. 1 – appointed an Inspector of Mines.

<sup>24</sup> *Daily Telegraph*, 20 December 1887, p. 3; *ibid.*, 30 August 1888, p. 3.

<sup>25</sup> *Launceston Examiner*, 30 July 1887, p. 2; *ibid.*, 2 September 1887, p. 2; *ibid.*, 1 October 1887, p. 2.

<sup>26</sup> *Ibid.*, 5 October 1887, p. 3; *ibid.*, 29 July 1887, p. 3.

<sup>27</sup> *Ibid.*, 27 October 1887, p. 3; *ibid.*, 17 November 1887, p. 3; *ibid.*, 30 November 1887, p. 3; *ibid.*, 17 December 1887, p. 3; *ibid.*, 22 December 1887, p. 3.

<sup>28</sup> *Daily Telegraph*, 10 February 1888, p. 3; *Launceston Examiner*, 25 August 1888, p. 3; A. Montgomery, 'The mineral resources of Tasmania', October 1894, MININD1894, *Mineral Resources Tasmania* [hereafter *MRT*], p. 117 – output of 281t stated for the period July 1883-December 1887 more likely to

relate to 1886-87; output reported in following three shareholder reports = 267.5t: *Launceston Examiner*, 5 August 1886, p. 3 – 94.5t; *ibid.*, 29 July 1887, p. 3 – 54t; *The Argus*, 1 February 1887, p. 7 – 119t.

<sup>29</sup> *The Argus*, 1 February 1887, p. 7; *Launceston Examiner*, 9 June 1887, p. 3; *ibid.*, 28 January 1888, p. 3.

<sup>30</sup> P.B. Nye, 'The Sub-Basaltic Tin Deposits of the Ringarooma Valley', *Geological Survey Bulletin* [hereafter *GSB*], no. 35, September 1924, p. 44; MIN120/1/1 – 80ac (20ha) Lease 316 granted to Fred. Krushka 1<sup>st</sup> November 1876, *TAHO*; for Briseis Hill photograph see *Journal of Australasian Mining History*, vol. 15, Figure 6, p. 132.

<sup>31</sup> *Launceston Examiner*, 3 August 1889, p. 3.

<sup>32</sup> 'Registers of applications for water rights', MIN90/1/1 – 7ac (2.8ha) mining easement as WR 139W granted 1 July 1885, *TAHO*.

<sup>33</sup> MIN120/1/1 – Krushka Brothers WR 91 for 25 SH [sluice-heads] from the Cascade River granted 1 July 1884, extended across the lease holdings of both the Briseis Co. & BH1 Co, *TAHO*.

<sup>34</sup> *The Cyclopaedia of Tasmania*, 1900, vol. 1, p. 510; *Launceston Examiner*, 4 December 1884, p. 3; *ibid.*, 30 April 1888, p. 3 – large tunnel section 10ft by 8ft high to accommodate both the boxed timber tailrace for washdirt tailings and a steel tramline for overburden disposal.

<sup>35</sup> *Launceston Examiner*, 25 December 1884, p. 3; *Daily Telegraph*, 21 March 1885, p. 3; *ibid.*, 6 May 1885, p. 3.

<sup>36</sup> *Daily Telegraph*, 13 July 1883, p. 1 – Briseis Co. registered with nominal capital £60,000; progress reports: *Launceston Examiner*, 3 March 1885, p. 3 – 128ft driven; *Daily Telegraph*, 6 August 1885, p. 2 – 290ft; *Launceston Examiner*, 2 January 1886, p. 2 – 455ft; *The Argus*, 28 February 1887, p. 11 – 950ft; *Launceston Examiner*, 25 May 1887, p. 3 – 1059ft; *ibid.*, 30 April 1888, p. 3 – final blast 24 April; *ibid.*, 28 April 1893, p. 3 – average cost of 1,080ft hard rock section £8-11s per foot (labour component 56%, expendables & equipment maintenance 35%); *The Argus*, 9 January 1888, p. 10 – total mine development expenditure £27,148.

<sup>37</sup> J. Harcourt Smith, 'Report on the alluvial tin mines at Derby', OS 141, 1 May 1899, pp. 3-4, *MRT*.

<sup>38</sup> *Ibid.*, 5 October 1888, p. 3; *ibid.*, 17 October 1888, p. 3; *ibid.*, 30 January 1889, p. 3.

<sup>39</sup> *Launceston Examiner*, 16 October 1889, p. 3 – 'running ground' referred to slurry-like, saturated sediments.

<sup>40</sup> *Ibid.*, 2 January 1890, p. 2; *Daily Telegraph*, 20 March 1890, p. 3.

<sup>41</sup> *The Mercury*, 15 February 1888, p. 3; *Launceston Examiner*, 30 April 1888, p. 3; *Daily Telegraph*, 11 November 1889, p. 3; Drawing 0349-016, untitled plan of Briseis underground workings produced by surveyor S.P. Ellis, 24 December 1890, *MRT*.

<sup>42</sup> *Daily Telegraph*, 17 November 1889, p. 3; *ibid.*, 28 June 1890, p. 8; *Journals of the House of Representatives*, Tasmania [hereafter *TPP*] vol. 43, no. 63, 1 September 1900, p. 26 – Krushka Brothers lease finally purchased for £35,000.

<sup>43</sup> *Launceston Examiner*, 24 July 1886, p. 3; *ibid.*, 19 January 1887, p. 3.

<sup>44</sup> 'Register of applications of water rights from the Derby Office', AC39/1/1, *TAHO* – application for 132ft drainage tunnel as WR 242W, 20 December 1886, granted 1 May 1889; MIN 90/1/1 – easement for winding shaft and main drainage tunnel about 400ft in length and 8ft wide as WR 260W granted 1 May 1887, *TAHO*.

<sup>45</sup> *Launceston Examiner*, 23 March 1887, p. 3; *ibid.*, 10 May 1887, p. 3; *Daily Telegraph*, 11 February 1889, p. 3 – hoisting gear driven by two pelton wheels supplied by a 6 inch pipe column from the Cascade River water race.

<sup>46</sup> *Daily Telegraph*, 30 July 1887, p. 3; *ibid.*, 20 December 1887, p. 3 – pelton wheel of 64in diameter; *Australian Ironmonger*, vol. 3/4, April 1888, p. 111 – 6 inch supply pipeline provided 12.5 psi (86kPa) generating 20 h.p. (15kW).

<sup>47</sup> *Launceston Examiner*, 19 May 1887, p. 3; H.L. Wilkinson, 'The deep leads of Victoria', *Proceedings of the Victorian Institute of Engineers*, vol. 4, 1905, p. 263 – timber of 8 inch section used for wash drives costing 4s 6d to 18s per foot, 25 inch timber used in reef drives at 4ft centres.

<sup>48</sup> *Ibid.*, 24 June 1887, p. 3; *ibid.*, 30 June 1887, p. 3.

<sup>49</sup> *Ibid.*, 28 October 1887, p. 3; *Daily Telegraph*, 20 December 1887, p. 3.

<sup>50</sup> *Ibid.*, 28 January 1888, p. 3 – underground development included 29 drives totalling 4,246ft, of which 3,538ft was in washdirt; *ibid.*, 28 July 1888, p. 3 – additional 2,140ft of crosscuts driven, revenue £4,345, expenditure £5,286; *ibid.*, 2 February 1889, p. 6.

<sup>51</sup> *Ibid.*, 2 February 1889, p. 6.

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- <sup>52</sup> *Ibid* – output 181t, revenue £12,410; *The Age*, 13 February 1889, p. 9 – gross profit £5,278; *Daily Telegraph*, 28 October 1889, p. 3 – mine manager replaced by J.M. Potter.
- <sup>53</sup> *Ibid.*, 7 March 1889, p. 3; *The Mercury*, 2 October 1894, p. 3 – 16 nominal horsepower Marshall portable steam engine fitted with 4.5ft winding drum; *Launceston Examiner*, 19 July 1889, p. 3; ‘Results of rainfall observations made in Tasmania’, *Commonwealth Bureau of Meteorology*, 1936, p. 56 – Scottsdale rainfall total for 1888 some 26% below the 49-year mean value.
- <sup>54</sup> *Ibid.*, 13 August 1889, p. 3; *ibid.*, 13 March 1890, p. 3; *Daily Telegraph*, 26 April 1890, p. 1.
- <sup>55</sup> J. Beswick, pp. 69-88 & 102-04 for further details of the company changes.
- <sup>56</sup> *The Argus*, 25 September 1889, p. 3; *ibid.*, 13 March 1890, p. 3.
- <sup>57</sup> *Launceston Examiner*, 24 June 1890, p. 4; *ibid.*, 3 July 1890, p. 3; *The Mercury*, 21 August 1890, p. 4; *Daily Telegraph*, 7 February 1891, p. 3.
- <sup>58</sup> Drawing No. 0248-004, untitled plan of No. 3 Level produced by surveyor Solomon P. Ellis, 8 November 1890, updated 19 December 1890, *MRT*.
- <sup>59</sup> *Daily Telegraph*, 1 November 1890, pp. 3 & 8.
- <sup>60</sup> *The Mercury*, 27 May 1891, p. 4; Drawing No. 0349-016, untitled plan of Briseis underground workings produced by surveyor S.P. Ellis, 24 December 1890, *MRT*.
- <sup>61</sup> B.H.G Brady & E.T. Brown, *Rock Mechanics for Underground Mining*, George, Allen & Unwin, 1985, p. 405 – ‘trough subsidence ... associated with the extraction of horizontal or flat-dipping orebodies overlain by weak, non-brittle sedimentary strata’.
- <sup>62</sup> *Daily Telegraph*, 4 July 1890, p. 4; *Commonwealth Bureau of Meteorology*, 1936, p. 56 – combined rainfall for June-July of 14.8in – 40.6% above the 49-year mean.
- <sup>63</sup> T.W. Lambe & R.V. Whitman, *Soil Mechanics, SI Version*, 1979, John Wiley & Sons: for shear strength of soils.
- <sup>64</sup> R. Brough Smyth, p. 621: ‘set of timber – consists of a ground-sill, two leg pieces [uprights], and a cap-piece ... employed for securing drives or levels, and they are placed at distances varying from four to six feet, and are connected by slabs’.
- <sup>65</sup> *The Mercury*, 27 May 1891, p. 4 – survey of surface cracking indicated horizontal displacement to the west of between 35in and 76in.
- <sup>66</sup> *Ibid.*, 27 May 1891, p. 4 – Supreme Court comprised Chief Justice (later Sir) William Lambert Dobson and puisne Justices (later Sir) John S. Dodds & Robert P. Adams.
- <sup>67</sup> *Ibid.*, 27 May 1891, p. 4.
- <sup>68</sup> *Ibid.*, 27 May 1891, p. 4; *Daily Telegraph*, 6 October 1891, p. 3.
- <sup>69</sup> *Ibid.*, 9 December 1891, p. 3; *The Argus*, 1 January 1892, p. 7.
- <sup>70</sup> L.F.S. Hore, *Digest of cases decided in Tasmania 1856-1896*, The Southern Law Society of Tasmania, 1897, p. 36.
- <sup>71</sup> *Launceston Examiner*, 19 March 1892, p. 2; *Daily Telegraph*, 13 September 1892, p. 3; *Ibid.*, 27 September 1892, p. 2.
- <sup>72</sup> ‘Plan of North Bros Home No. 1 Tin Mining Co. No. 4 Level’, Drawing No. 0248-001, 14 March 1893, *MRT*.
- <sup>73</sup> *Daily Telegraph*, 17 August 1893, p. 4 – weekly output typically 4t through to October; *Launceston Examiner*, 5 February 1894, p. 7 – 3 pence dividend paid 28 February at a cost of £750; *The Age*, 2 March 1894, p. 3 – 3 pence dividend; *ibid.*, 9 April 1894, p. 8 – 3 pence dividend.
- <sup>74</sup> *Ibid.*, 1 October 1894, p. 6; *Daily Telegraph*, 5 October 1894, p. 3.
- <sup>75</sup> *Ibid.*, 5 February 1889, p. 4 – Triangle & NBH Amalgamated Tin Mining Co. registered in Melbourne with nominal capital £15,000, working capital £1,000.
- <sup>76</sup> *The Mercury*, 6 February 1889, p. 3; *The Argus*, 14 February 1889, p. 9; *Launceston Examiner*, 3 August 1889, p. 3; *ibid.*, 2 January 1882, p. 3 – James Brown first mine manager of NBH Co. January 1882 – January 1884.
- <sup>77</sup> *Ibid.*, 3 May 1889, p. 3; *ibid.*, 16 July 1889, p. 3; *Daily Telegraph*, 13 June 1889, p. 3.
- <sup>78</sup> MIN90/1/1 – application for 20 SH as WR 252-87W granted 2 May 1889, *TAHO*; *ibid.*, a previous water right of 50 SH from the Ringarooma River as WR 124W for the same purpose cancelled 4 January 1887, *TAHO*.

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- <sup>79</sup> *Launceston Examiner*, 22 October 1889, p. 3; *ibid.*, 26 November 1889, p. 3; *Daily Telegraph*, 26 November 1889, p. 3; *TPP*, vol. 20, no. 64, 21 July 1890, p. 7 – tribute party of 23 European miners described as the ‘most numerous ... in this district’.
- <sup>80</sup> *The Mercury*, 21 August 1890, Supplement, p. 2.
- <sup>81</sup> *Daily Telegraph*, 4 July 1890, p. 4; *ibid.*, 5 September 1890, p. 4; *The Mercury*, 21 August 1890, Supplement, p. 2.
- <sup>82</sup> *Launceston Examiner*, 20 November 1890, p. 3; *ibid.*, 4 June 1891, p. 3; see Appendix 1 for the diminishing water rights granted to the NBH Co. since construction of the headraces in 1883.
- <sup>83</sup> *Ibid.*, 28 May 1891, p. 3; *Daily Telegraph*, 25 November 1891, p. 3; *ibid.*, 26 January 1892, p. 3.
- <sup>84</sup> Drawing No.0271-002, ‘Plan of the Triangle & NBH TM Co’, undated, probably December 1892, *MRT*.
- <sup>85</sup> *The Argus*, 10 February 1883, p. 15; *Launceston Examiner*, 23 June 1883, p. 2; Drawing No. 0271-001, ‘Plan of the Triangle & NBH TM Co. underground workings’, 31 January 1894, *MRT*.
- <sup>86</sup> *Launceston Examiner*, 7 August 1893, p. 7; *ibid.*, 10 January 1894, p. 2; *Daily Telegraph*, 4 October 1893, p. 4 – last reported production of 2.6t.
- <sup>87</sup> *Ibid.*, 31 October 1895, p. 2 – syndicate of nine initially, led by chairman William T. Tucker & miner William H. Hills; *Walch Almanac*, 1890, p. 270.
- <sup>88</sup> MIN 90/1/2, transfer 2 SH as WR 20-93W from Boyd’s Creek & 10 SH as WR 93-93W from Pearce’s Creek (now Fenckers Creek) & French’s Creek some 19.5ml from the mine site, 14 September 1900.
- <sup>89</sup> *Launceston Examiner*, 2 September 1896, p. 6; *ibid.*, 13 October 1896, p. 3.
- <sup>90</sup> *Daily Telegraph*, 24 July 1897, p. 8; *Launceston Examiner*, 17 November 1897, p. 7.
- <sup>91</sup> MIN90/1/2, application for 10 SH as WR 211-93W, 21 December 1897, *TAHO*; *The Mercury*, 26 March 1898, p. 1; *Ibid.*, 2 March 1898, p. 3; *TPP*, vol. 39, no. 51, July 1898, p. 19; Untitled plan of WR 38-93W, 30 April 1898, *MRT*.
- <sup>92</sup> MININD1898-4, December 1898 p. 6; *ibid.*, MININD1899-4, December 1899, p. 4, *MRT*; *Launceston Examiner*, 17 October 1899, p. 2.
- <sup>93</sup> *The Examiner* [title change from *Launceston Examiner*], 9 June 1900, p. 7; newspaper reports indicate a dividend return exceeding 450% over a four year period; *ibid.*, 20 August 1900, p. 2 – T.H. Clouston a mining engineering graduate of the London Royal School of Mines that amalgamated in 1907 to form the Imperial College of Science & Technology.
- <sup>94</sup> *The Examiner*, 9 June 1900, p. 6; *ibid.*, 20 August 1900, p. 2.
- <sup>95</sup> *Ibid.*, 19 June 1901, p.2 – pumping plant cost £8,000; *Australian Mining Standard*, 18 July 1901, p. 86.
- <sup>96</sup> *Ibid.* 29 June 1901, p. 6; *Daily Telegraph*, 6 August 1901, p. 4.
- <sup>97</sup> *Ibid.* 2 May 1902, p. 2; MININD1902-4, December 1902, p. 8, *MRT*.
- <sup>98</sup> *TPP*, vol. 47, no. 13, 18 September 1903, pp. xxxix & xlii.
- <sup>99</sup> MININD1902-4, December 1902 p. 8, *MRT*; *Daily Telegraph*, 5 August 1903, p. 8.
- <sup>100</sup> *The Mercury*, 16 September 1903, p. 3; *The Examiner*, 30 October 1903, p. 2; *The Mercury*, 10 May 1906, p.7 – only £4,000 secured for dredging plant with a projected cost of £10,000.
- <sup>101</sup> *The Examiner*, 22 September 1904, p. 2; *ibid.*, 12 October 1904, p. 7.
- <sup>102</sup> *The Examiner*, 4 May 1906, p. 2; *Daily Telegraph*, 3 July 1907, p. 2; *The Cyclopaedia of Tasmania*, vol. 1, 1900, p. 512 – Briseis Tin Mines Ltd registered London in November 1899 with a capitalisation of £600,000, purchased the Briseis property for £150,000 cash and £200,000 in shares.
- <sup>103</sup> MININD1907-4, December 1907 p. 10, *MRT*; MIN90/1/3, Briseis Tin Mines Ltd application for a 1,980ft long pipeline easement as WR 756W, 11 April 1907, *TAHO*.
- <sup>104</sup> *The Argus*, 29 April 1902, p. 8; *Examiner*, 28 November 1902. p. 2; H.A. Gordon, *Mining and Engineering, and Miners’ Guide*, New Zealand Government Printer, 1894, p. 212: a similar discharge rate of approximately 40 Tasmanian sluice-heads is indicated for a 30 inch diameter pipe having a grade exceeding 1 in 10.
- <sup>105</sup> *GSB*, no. 35, p. 46 – estimated tin output to December 1899 of 9,600 tons formed approximately 34% of the total estimated production from the Cascade Lead to the cessation of mining in 1960, published outputs for the various operations given in Table 1 amount to some 76% of the estimated output to December 1899.