

## **Mount Bischoff Tin Mines: Pioneers of water power in the Tasmanian mining industry**

By KEITH PRESTON

‘**L**ifeblood of the colony’ is a phrase that has been used in relation to the extensive use of water for irrigation in Tasmania during the 19<sup>th</sup> century and also the hydro-electric power developments during the 20<sup>th</sup> century.<sup>1</sup>

The widespread use of water, both for mineral processing and power generation, was equally the lifeblood of the Tasmanian tin mining industry, and especially at Mount Bischoff. Water power was widely used on most of the tin mining fields in Tasmania, particularly the Heemskirk and Waratah fields on the west coast, and in the North East district at the Mt Victoria, Blue Tier and Ringarooma River (Gladstone - Derby) fields.

The discovery and early development at Mount Bischoff has been well documented in a number of publications and only a brief outline follows.<sup>2</sup> The orebody was discovered by James (‘Philosopher’) Smith in December 1871, a track had been established to the mine site by the following August and mining commenced on 14<sup>th</sup> December 1872. The early mine development was directed by Canadian William Crosby assisted by James Smith. Following the shipment of several tons of ore to Melbourne in mid-1873, the Mount Bischoff TM Co. was registered in August and a working capital of £15,000 established for the initial development. Heinrich Wilhelm Ferdinand (‘Ferd’) Kayser took up his appointment as mine manager in November 1875 due to Crosby’s retirement and proceeded to direct the mining operations over an unbroken thirty-year period and establish Mount Bischoff TM Co. as an unrivalled jewel of the Tasmanian tin mining industry. Kayser claimed that the first dividend payment was delayed until February 1878 due to

the bad state of the road between Bischoff and Emu Bay, as by the end of the year 1877 we had over 1,585 tons of ore at the works, which had to be carted, during January, February and March, and smelted [in Launceston] before the money was available.<sup>3</sup>

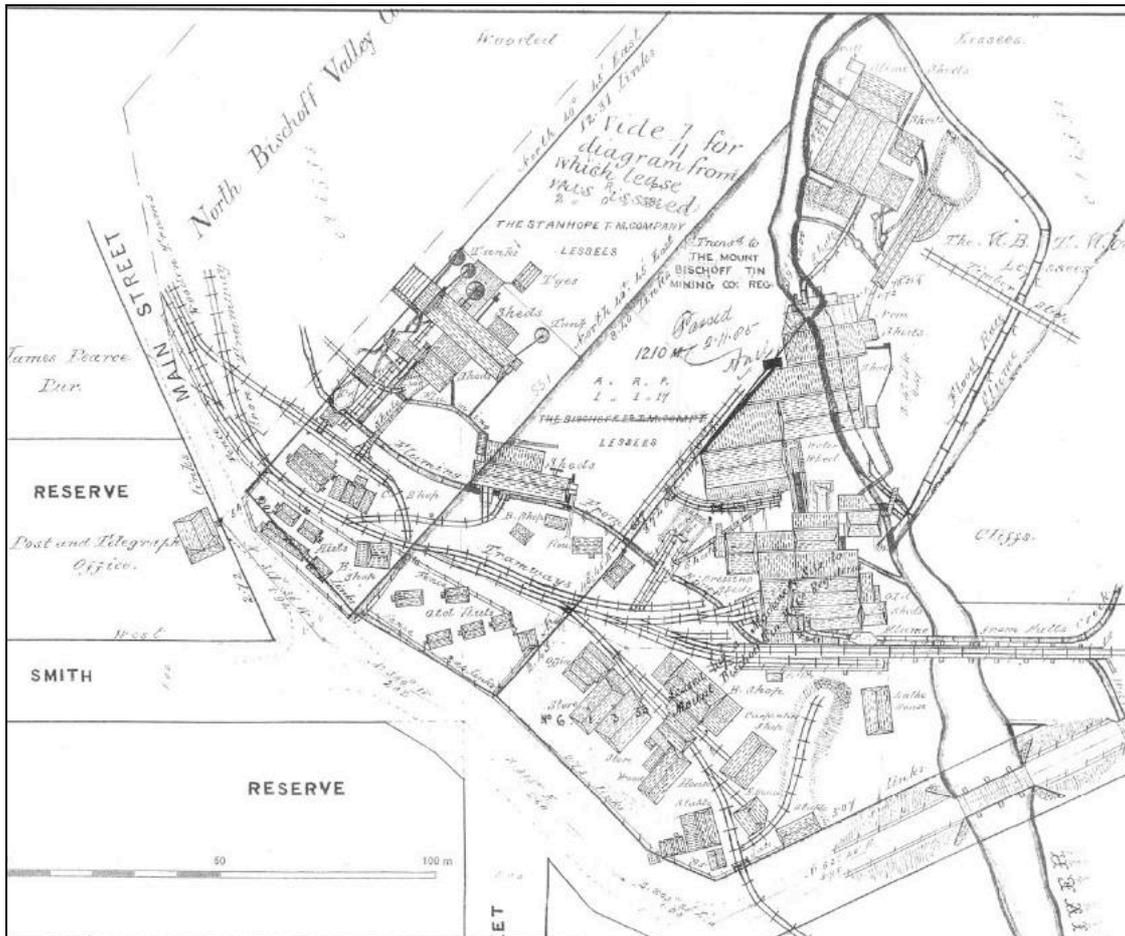
This paper outlines both the application of water power at the mine sites and the steps taken by the various mining companies that operated at Mount Bischoff between 1875 - 1940 to provide the copious quantities of water required. Within a few years the

Mount Bischoff TM Co. became the largest company and had an unrivalled reputation for profitability during the period when Kayser was in charge. All of the surrounding mineral leases were eventually acquired in order to obtain additional ore reserves and to enable expansion of operations to the east and north of Mount Bischoff to proceed.

### **Initial Developments to July 1875**

The mineral leases that were initially developed on the southern flank of Mount Bischoff included those of the Mount Bischoff TM Co., and the adjoining leases operated by Cummings Henry & Co. and the Stanhope TM Co. of A.M. Walker and Beecraft (Fig. 1). These three operations collaborated to establish a tramway to the top of the Waratah Falls that had been constructed by May 1874. As the Mines Department

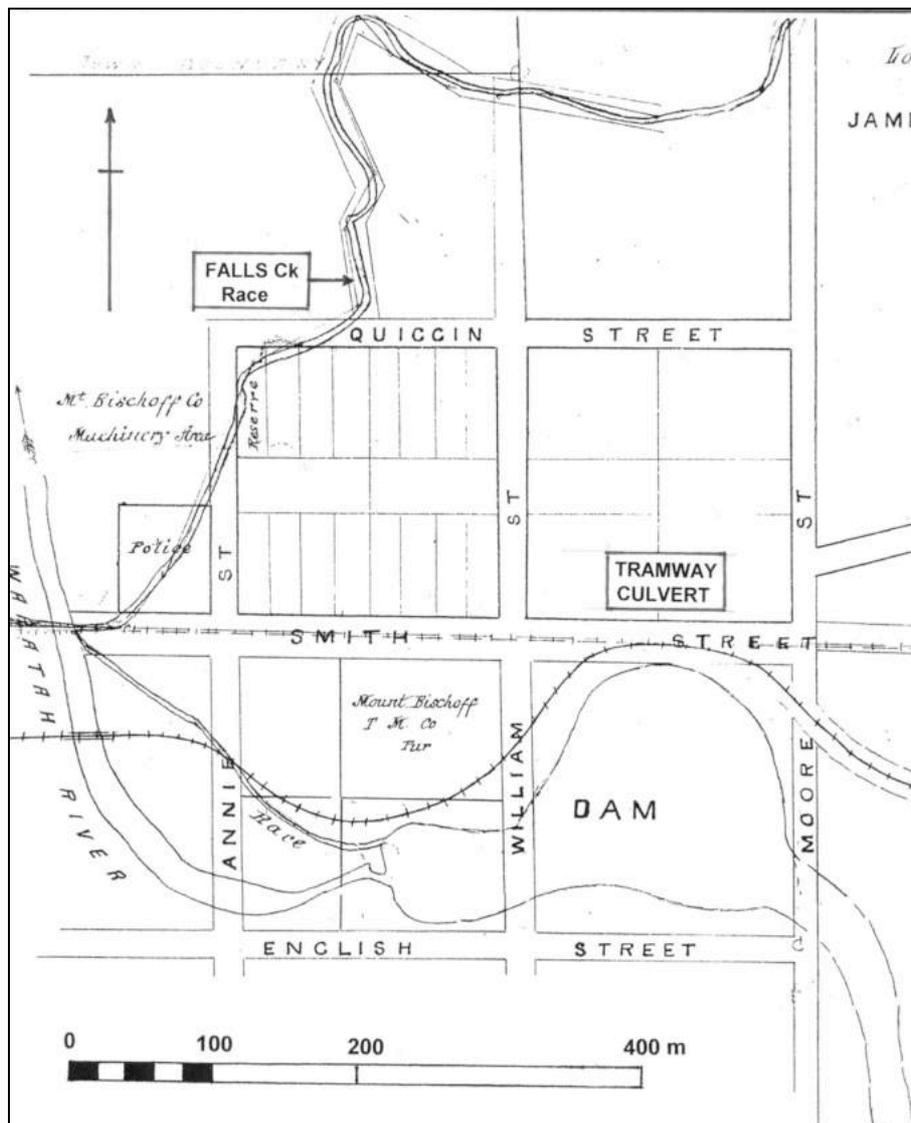
**Figure 1:** Initial surface infrastructure on the leases of the Mount Bischoff TM Co. to the east, Walker & Beecraft adjoining to the west and the Stanhope TM Co. showing the tramways, processing sheds, supply flumes from the Waratah and Falls Creek dams, and waterwheels.



Source: MRT 'Plan of the Machinery Sites', David Jones surveyor, March 1884.

had yet to establish the water rights to the Waratah River, the Mount Bischoff TM Co. constructed a dam on their northern lease having an area of '4 chains square' and depth of 1.7m. In order to conserve water both for sluicing and processing, a second-hand vertical steam engine was acquired together with a centrifugal pump to raise water up to the sluice boxes which then ran back into the dam. This procedure enabled 0.5 - 2 tonnes to be washed per day.<sup>4</sup> As the engine was described as being in poor condition requiring constant repairs, this practice was discontinued in May 1875 when water became available from the newly-commissioned supply dam on the Waratah River.<sup>5</sup> This was to be the only application of steam power by the Mount Bischoff TM Co.

**Figure 2:** First storage dam on the Waratah River and the confluence of the Waratah race, the Falls Creek race extending around the cliff top and the Tramway Culvert extending along Smith Street.



Source: MRT Plan 65 Sheet 3, Charles Sprent surveyor, November 1882

This dam was jointly financed by the three companies who shared the water entitlements equally. It was located within the town precinct and referred to as the 'Town Dam' (Fig. 2). The 4m high embankment with a length of some 30m was constructed to established practices at that time, comprising outer log walls battered at 65° that were infilled with 'dirt'. A water race 1.5m wide and 0.9 - 2.15m deep was cut in the basalt bedrock to convey the water to fluming that extended across the newly constructed Waratah Bridge and onto the company leases (Fig. 1). This bridge also enabled a horse tramway to be extended from the mine sites to Rouse's Camp which initially formed the terminus of the Van Diemen's Land Co's tramway. This had been largely completed by July 1875.<sup>6</sup>

Developments on the adjoining leases also proceeded apace with the Waratah dam construction. Cummings & Henry had erected a machinery shed enabling sluicing to commence on 14<sup>th</sup> June, 24 truckloads of ore being hauled a kilometre from the face along a horse-drawn tramline. Processing of the tin was limited to the use of long sluice boxes for gravity separation and grading in conjunction with a buddle. The Stanhope TM Co. had two sluices and two buddles operating by March producing 5 tonnes per week when 'the mode of pumping the water for dressing the tin is by means of an American horse treadle machine and Californian pumps'.<sup>7</sup> Construction of their dressing shed of 7m x 33m dimensions had commenced by July on a site having a 16m fall from the supply flume that was being extended from the MB TM Co. workings.<sup>8</sup>

### **Introduction of Water Power July 1875 – January 1878**

The Mount Bischoff TM Co. had commenced construction of their first dressing shed in April 1875 under the supervision of mill manager Stephen Eddy and overall direction of William Crosby who promoted the introduction of water power.<sup>9</sup> By July an extension was underway to enclose a 6.1m diameter waterwheel:

It is a high breast wheel and will make in working 20 revolutions a minute. It is built on a centre piece, or nave of wood, through which the shaft passes, and as yet works on wooden bearings. The arms cross each other diagonally at the centre of the arms, where they are let into each other a little ... attached to the shaft is a large pulley, 16 feet in diameter, which will drive a counter shaft being connected by a tooth and pinion wheel to the trammel or revolving cylinder, which will be the first to receive the washdirt from the paddock, and separate the nuggets from the fine by means of concentric screens.<sup>10</sup>

The waterwheel appears to be shown on Figure 1 at the eastern end of the 'Old Sheds', the supply fluming having been removed following the installation of a replacement waterwheel (see below). From the description reproduced above, it is clear that the waterwheel was of all timber construction, even the bearings, which must have been a temporary measure to overcome delays in sourcing materials. This was due to the difficulties of transporting materials some 60km overland by packhorse along unformed tracks from Emu Bay (Burnie), the nearest dock with a crane for unloading.

William Cosby was forced to resign due to ill health and was replaced by Kayser at the mine in November to oversee additions to the processing plant (jigging machines, a rotating buddle and three classifying boxes) that required an extension to the dressing shed. The jigging machines were driven by eccentric rods from the waterwheel shaft. A second-hand five head stamp battery (5 HB) was operational by December 1876 and it soon became apparent that additional power was required.<sup>11</sup> Dressing operations were suspended during March to enable a larger 8.5m high breast wheel to be erected:

The arms are fitted on to large cast iron centres, 13 cwt each, keyed on to a large shaft. The centres were cast in Melbourne. There are three altogether, the wheel is built on two, the remaining one being for the driving wheel. The segments of the periphery of the water wheel are strengthened with plates of iron let into the wood at the joints, flush, and bolted securely.<sup>12</sup>

The position of the waterwheel within the first of the 'Old Sheds' shown on Figure 1 can be inferred by the fluming extending from the main supply race from Falls Creek (see below).

Development work on the Stanhope TM Co. lease was also proceeding following the transfer of ownership to a Victorian syndicate and the appointment of Cornishman, Captain Taylor in September 1875. A wood-fired reverberatory furnace was erected at the mine site and trialled the following February, smelting of a ton of ore requiring 5 - 6 tonnes of wood. By May 1876, dressing was achieved by means of a trommel and hydraulic classifier driven by a small 1.8m diameter high breast waterwheel.<sup>13</sup> A waterwheel-powered 8 HB was also being erected at this time and was operating by the following March. This was driven by a 6.1m diameter overshot wheel that also powered 'a couple of rollers for crushing the charcoal used as a flux in the smelting furnaces and for winding the dressed ore up to the tramroad level'.<sup>14</sup> The top of the waterwheel is visible in Figure 3 and is shown on the mine plan (Fig. 1).

**Figure 3:** *A view looking towards the southeast from Main Street showing the Stanhope TM Co's processing plant in the foreground. The battery shed powered by an overshot waterwheel is located at the extreme right hand side.*



Source: Pioneer Museum, Burnie

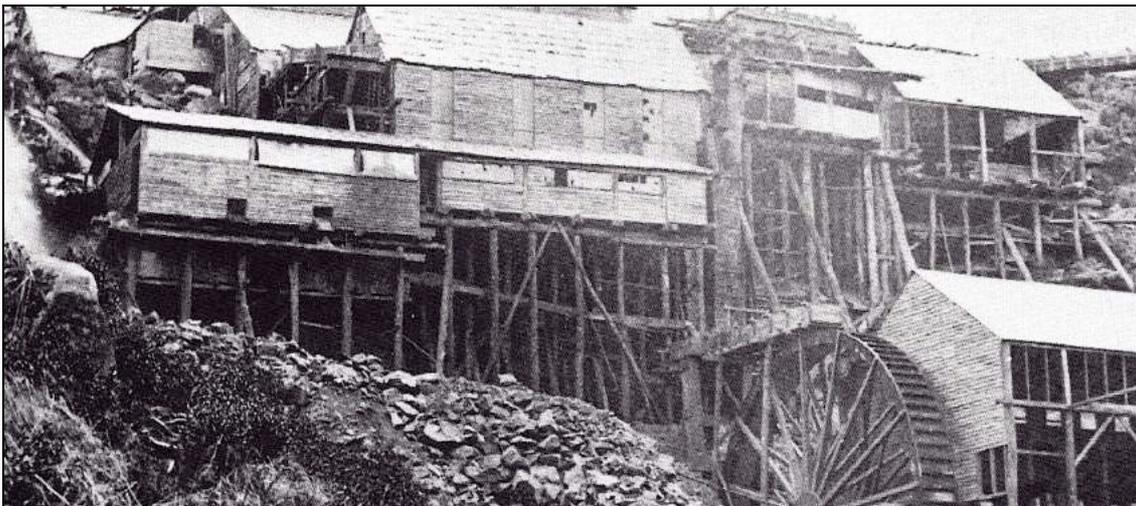
### **Mt Bischoff TM Co.: Expansion 1878 – 1880**

A second waterwheel of 6.1m diameter had been installed in the dressing shed by January 1878, the move no doubt instigated by increased power requirements from further plant additions. At this time, Kayser considered erecting a 40 HB at the foot of the Waratah Falls to be powered by a 26kW turbine where a 15m fall was available after water was discharged from the lower waterwheel. The turbine had arrived at Rouse's Camp the following month together with the associated shafts and gearing.<sup>15</sup> A change of plan had eventuated later in the year however, when it was revealed that the Launceston foundry of Salisbury and Armstrong was fabricating shafts and bearings, and producing castings for the centres of another large 12.2m waterwheel weighing two tonnes each, together with a 2.5m diameter spur wheel weighing three tonnes. These are believed to be the first locally manufactured iron castings to be used at Mount Bischoff. The iron components were shipped on board the *SS Amy* in January 1879 and conveyed to Penguin Creek because landing at Emu Bay was prevented by the crane being out of

action. They were transported to the mine site by packhorse contractor William H. Cann using a team of 20 bullocks, who had to provide additional props to the Blythe Bridge to support the weight.<sup>16</sup> This remained the only transport option for conveying heavy machinery to the mine site until the Van Diemen's Land Co. tramway that was provided with iron rails, was extended to Waratah in 1884.<sup>17</sup>

The excavations for the large waterwheel and battery shed together with the installation of equipment took most of the following year to complete and the battery was not commissioned until the 1<sup>st</sup> October 1880.<sup>18</sup> A photograph taken during construction (Fig. 4) shows a waterwheel of pitchback construction, locally sourced timber being used for most of the wheel components including the shroud and buckets. Overshot or pitchback waterwheels constructed largely of timber had a maximum theoretical efficiency of 70 percent but this was often reduced depending on the quality of workmanship, the frequency of repairs and maintenance standards.<sup>19</sup> As a result of the extended construction period of the new battery, an urgent requirement for an increased crushing capacity was solved in July 1879 by installing a 15 HB to replace the 5 HB. This commenced work on 10<sup>th</sup> September 1879.<sup>20</sup>

**Figure 4:** *Mount Bischoff TM Co's 40 HB during construction, powered by a large 12.2m diameter waterwheel and the earlier dressing sheds constructed upslope by 1878 (referred to as the 'Old Sheds' in Figure 1).*



Source: Pioneer Museum, Burnie.

Mining of the southernmost face on the Mount referred to as the Happy Valley Face at the head of Slaughter House Gully, resulted in a large volume of tailings

accumulating by the end of 1877.<sup>21</sup> In order to recover the fine tin from these deposits, Kayser ordered construction of a small plant in the gully, immediately above the boundary of the Waratah TM Company's lease. This was powered by a 'wrought iron waterwheel ... of about 15 feet [4.6m] in diameter by two feet in width, and will be driven by the water which has been previously used in the sluices above'.<sup>22</sup> This implies that some components, possibly the buckets, were constructed of wrought iron plates but there is insufficient detail for further conclusions to be drawn. The plant operated for little more than a year as the purchase of the Waratah TM Co's assets enabled the more extensive Ringtail Sheds to be erected at the foot of the gully, adjacent to the Waratah River.<sup>23</sup>

### **North Bischoff Valley TM Co. Operations 1878 – 1882**

The prospectus issued in January 1878 indicated that a capital of £13,000 was available for the initial site development. A syndicate of Edward B. E. Walker, Joseph Raymond and Thomas Thoms held three 80-acre sections and Henry Ritchie was appointed the legal manager, William Dick the mine manager. Work was underway by April when an extension to the Waratah flume from the Stanhope TM Co's lease was proceeding. The Langlands Foundry Company in Melbourne had been contracted to fabricate machinery which was to be dispatched the same month.<sup>24</sup> Little progress appears to have been made during the next eight months as in January 1879 a tender of £1,052 was accepted from the same foundry for the supply of a 10 HB and dressing machinery. The waterwheel pit was being excavated during March when progress with the construction of the remaining fluming and waterwheel had slowed due to a shortage of carpenters. The battery was finally commissioned at the end of December, powered by a 6.1m diameter breast waterwheel.<sup>25</sup>

The reason for the protracted construction is likely to have been a water supply problem, as the three companies that had financed the first dam construction controlled the Waratah River flows. An agreement must have been reached with one or more of these parties but a shortage was indicated by the need to construct a storage dam on Camp Creek below the processing plant for recycling. A force pump was used to raise water 7.5m into a tank to operate the battery. The excavation of a water race and construction of fluming to supply the dam in July 1882 suggests that water supply remained a problem which limited operations.<sup>26</sup>

### **Mount Bischoff TM Co.: Falls Creek dams and water race 1880 – 1884**

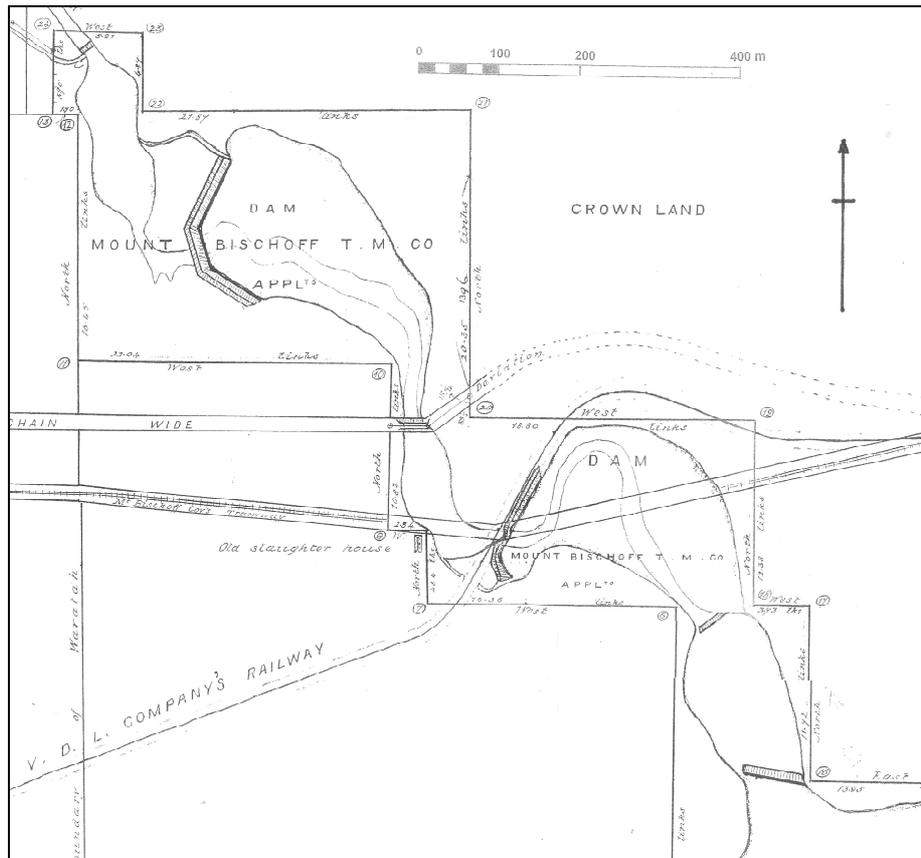
Sluicing operations were suspended in April 1879 due to a shortage of water which is likely to have induced Kayser to consider harnessing Falls Creek to the east of the township, a proposal first made by Crosby.<sup>27</sup> Kayser claimed that at his instigation ‘lengthy consultation about steam v. water’ took place with the company directors before the Falls Creek water supply scheme was pursued. Harnessing the waters of the Wandle and Fossey Rivers to the east and Coldstream River to the south was also considered at this time.<sup>28</sup> The survey of Falls Creek had been completed by January when a further water shortage, lasting until March limited working of the 15 HB to only five stamps. Given the impending introduction of the new 40 HB, larger water storage was becoming a critical issue for increased production. The first dam of ‘masonry and cement’ and the flumed race extending for approximately 2,415m around the cliff top to the Waratah Bridge had been completed by mid-1880. Kayser thought highly of the race that was completed in less than three months by contractor Samuel Pinnington.<sup>29</sup> This water was solely for use of the Mount Bischoff TM Co’s operations and was directed into the dressing sheds (Fig. 1).

During the next two years additional dams were constructed across Falls Creek. By August 1882, the water level in the ‘second dam’ was reported as having been raised to double the capacity, the Falls Creek reservoirs at this time having a total storage of 750ML.<sup>30</sup> The following February, construction of a further dam had commenced which perhaps explains the revision in April when five separate reservoirs were operating.<sup>31</sup> Additional storage capacity was reported to shareholders in August 1884:

The dam of the No. 1 reservoir on Falls Creek was also raised three feet, No. 4 dam is also finished and when the reservoir is full the water will be backed to the slaughter house, so that No. 3 reservoir, the dam of which is crossed by the main road to Waratah, and No. 4 will form one reservoir. I have commenced clearing the site for another dam on Falls Creek, just above the V.D.L Co’s railway bridge, where a large reservoir, probably the second largest on the creek, can be constructed.<sup>32</sup>

The changes are detailed on a plan prepared in September 1885 (Fig. 5). At the meeting, Kayser was confident that the Falls Creek reservoirs ‘will probably be of sufficient capacity to conserve water for all our requirements at Watatah’.<sup>33</sup>

Figure 5: 'Plan of the Mount Bischoff T.M. Co's Falls Creek Dams'.



Source: MRT Plan 65 Sheet 2, David Jones surveyor, September 1885.

### Mount Bischoff T.M. Co.: further expansion 1882 – 1887

Slime Sheds constructed along the northern side of the Waratah River (Fig. 1) were progressively commissioned during 1881-82 requiring the construction of fluming across the river to convey water from the 40 HB. The plant was driven by two waterwheels of 6.0m and 4.6m diameter.<sup>34</sup> Further down the valley the first of the Ringtail Sheds had been erected by August 1882 'at the foot of the tailings gully' to rework all of the tailings produced. This plant was driven by a 9.2m diameter waterwheel that was erected the following February. A detailed specification for an extensive list of ironwork that was issued to tenderers in July survives and this probably relates to the ironwork required for the Ringtail Sheds. The substantial contract was no doubt awarded to the Salisbury Foundry that appears to have been the preferred supplier of ironwork, the list including 17 shafts of up to 4.9m in length, a waterwheel shaft of 3.6m length and 190mm diameter, wheel centres of 1.7m diameter, and ten sets of

bevelled gearing.<sup>35</sup> A water race had been constructed from the foot of Waratah Falls by August 1884 to maintain operation during the summer months.<sup>36</sup>

In 1883 trials with electric lighting were underway when a dynamo was installed in the 40 HB shed to be driven from the waterwheel shaft. In March 1884 an electrical engineer arrived to ‘put the dynamo in order ... the only fault appears to be the unsteady motive power, but I think we can get over the difficulty by balancing waterwheel’.<sup>37</sup> It was not until the following January that Kayser reported that the teething problems had been resolved and the first successful industrial application of electric lighting in Australasia could be announced, ‘all the Waratah sheds, workshop, store and office are supplied with lamps, with the very best results and no difference is perceptible in the light of the lamps close to the dynamo and those furthest away’.<sup>38</sup>

A requirement for further crushing capacity had arisen by mid-1885 and new sheds were erected immediately to the north of the 40 HB. This 20 HB was to be driven by an iron waterwheel fabricated in the company’s workshops at Mount Bischoff. This was proceeding in November and construction of the wheel pit in the bed of the Waratah River was underway in February at a site described as being ‘beyond the reach of danger from an ordinary flood’.<sup>39</sup> The masonry work for the wheel pit was not completed until August 1886 when the waterwheel was ready for assembly. This had been achieved by the following February when the plant was ready to be started, the waterwheel used the water discharged from the 40 HB waterwheel, the shafts of both wheels being connected by belts to maximise the power generated.<sup>40</sup> The dimensions of the waterwheel appeared in later accounts, the *Town & Country Journal* recording a diameter of 7.3m and width of 1.2m in 1893, and Herman documenting a diameter of 8.5m in 1914, the latter being repeated in later accounts.<sup>41</sup>

The mine workshops were established in the former Cummings and Henry dressing shed, to which a waterwheel had been added by March 1884 as it is shown on Figure 1.<sup>42</sup> The workshops were expanded in 1886 to include foundry facilities and a Roots blower to provide the air blast, installation of the latter proceeding in February 1887.<sup>43</sup>

### **West Bischoff TM Co. operations 1881 – 1884**

Extensive development work commencing in March 1881 was required to exploit the leases on the southwestern flank of Mt Bischoff, largely because of the decision to utilise water power entirely for mineral processing when the use of steam engines might

have proved to be more economical. A site for the dressing shed was selected near the confluence of Tinstone Creek with the Arthur River (Fig. 6) so that a plentiful water supply could be obtained from the latter. A 460m long horse tramway led from the face to a self-acting incline that was connected to the dressing shed by another tramway 1,360m in length requiring the construction of a substantial bridge across Ritchie Creek. The mine manager, William White, described the works at a meeting attended by only fourteen shareholders:

Tin Creek Line – On this line we have made two big cuttings, one 4 chains long that will average 13ft deep and the other 2 chains long that will average 10ft deep, through rock, some of which was exceedingly hard. We have also erected on this line five bridges and four culverts. With one of these bridges we cross the Ritchie Creek Valley where it is 160ft wide and the top of the rail 32ft from the bed of the creek. At first I did not intend to make this bridge so high, but when we decided to make our water-wheel 28ft in diameter, instead of 20ft, I had to erect the tramway to correspond with this alteration.<sup>44</sup>

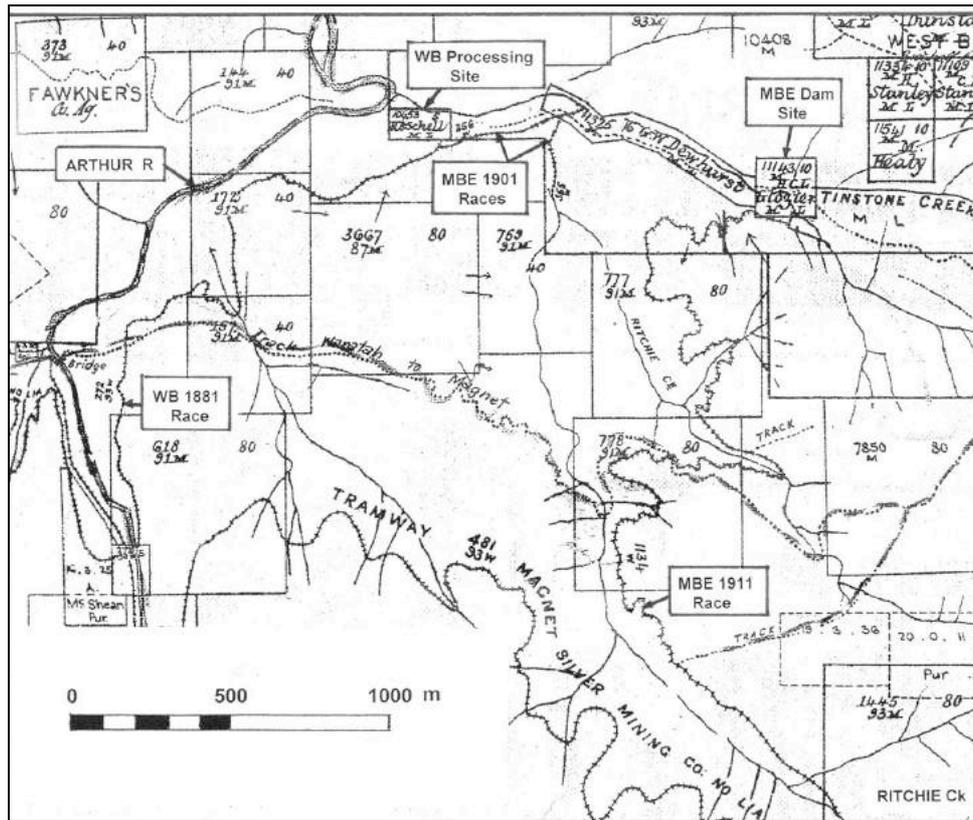
The alignment of the incline is shown on Figure 6 along with that of the 2,620m long water race that was largely excavated in basalt involving cuts up to 4m deep. Fourteen men were excavating this in August at a rate of 160 - 200m a week, which is consistent with the reported completion date at the end of February. Increased capital was required by December 1882 when it was revealed that the water race had absorbed £670 out of an initial capital raising of £5,000. The ironwork for the large overshot waterwheel driving a 15 HB and also a 2.4m diameter waterwheel to operate the dressing plant was supplied by the Salisbury Foundry. A fall in the price of tin by August 1883 resulted in the operation being only marginally profitable and unlikely to repay the development costs.<sup>45</sup>

### **Mount Bischoff TM Co.: the search for more water 1883 – 1886**

Alternative sources of water supply were being investigated towards the end of 1883, including the Coldstream and Fossey catchments to the south and east of Waratah respectively. In August, Kayser, the assistant manager Charles Hall and surveyor David Jones were travelling along the company's tramroad to Rouse's Camp to inspect the alignment for a new watercourse when the horse bolted and the truck left the rails. The occupants were thrown out of the truck but escaped serious injury.<sup>46</sup> The search had narrowed to the Fossey catchment by September 1884 when surveyor Sale estimated the

cost of constructing a 7,070m long race and fluming from the foot of Mount Pearce to the uppermost Falls Creed reservoir at £1,670. A tender for £2,700 was subsequently awarded in February for a 0.9m wide race constructed at an unusually low grade of 1 in 2,640 (0.02°) that Kayser expected to be completed within four months. It was to take double that time.<sup>47</sup>

**Figure 6:** Water races of the West Bischoff TM Co. (WB) and Mount Bischoff Extended TM Co. (MBE) supplying the processing plant in Tinstone Creek.



Source: MRT Plan W18, May 1936.

Before the Fossey Scheme was completed, another project was commenced to collect subsurface water by driving a tunnel along the company's tramway easement between the Waratah Bridge and the Falls Creek reservoirs. This 'tramway culvert', as it became known, was first announced to the shareholders at the January 1885 meeting after 443m had been driven. Kayser justified the expense by pointing out that 'the Falls Creek aqueduct is so close to the edge of the cliff that it is impossible to prevent leakage and the loss in this way is always greatest in summer when water is most valuable'.<sup>48</sup> A year later the total length had reached 583m with progress during the previous six months having reduced to 42m. A further 14m was driven in ten weeks at the beginning of 1886 before the 'lower level' was abandoned in favour of a combination of tunnels

and cuttings at shallow depth totalling 339m. By February 1887, a further 180m had been driven from four faces. In February 1888 completion of the 1,810m long culvert that was extended to connect with the Falls Creek dams was finally predicted for April after a titanic effort extending over a four year period. The cost of the Falls Creek dams, the Falls Creek race and the tramway culvert up to that date were estimated as approaching £10,000.<sup>49</sup>

### **Mount Bischoff TM Co.: North Valley workings 1886 – 1895**

This was a protracted project over a five year period commencing in January 1886 to exploit the lode at the northern end of the Mount Bischoff TM Co. lease. An exploratory adit was underway in January when the ore was described as poor and was being stockpiled separately. A dam across the Waratah River was under construction in conjunction with a water race between February-May 1886 when only the last section of fluming was outstanding.<sup>50</sup> The project then appears to have stalled until the following March when excavation for the waterwheel pit was described as ‘well advanced’ and a carpenter was engaged on preparing timber for the waterwheel. Further work on concreting the waterwheel pit was undertaken during May and June, after which the project appears to have stalled again. This was due to the occurrence of pyritic tin deposits that required alternative processing techniques to treat the sulphide-rich ore to be established.<sup>51</sup>

After a three year lull, the project was revived, as a 9.2m diameter iron waterwheel was being fabricated at the mine site in May 1889. Dressing machinery was ready to be installed by August but again the project slowed as the waterwheel components remained unfinished a year later and carpenters were employed on repairing the Falls Creek dams and fluming. During this period, fitters were at work installing revolving roasting furnaces to deal with the sulphide-rich ore and an air compressor, all to be driven by the waterwheel.<sup>52</sup> Erection of the waterwheel was finally underway in August but the plant remained to be commissioned in August 1891. Subsequent details went unreported and all mining at the North Valley had ceased by August 1895.<sup>53</sup> A 1914 account summarises the demise of a development that had cost an estimated £18,000:

This mill (the “North Valley”) apparently had very little ore to treat, and found difficulty in doing that successfully. It shut down after a brief run, and a bush fire relieved the company of the expense of a caretaker in 1906.<sup>54</sup>

### **Mount Bischoff Extended TM Co. 1899 - 1940**

The West Bischoff TM Co. operations had been acquired by the Mount Bischoff Extended TM Co. by February 1899 and the company was floated 18 months later raising a working capital of £16,000. The existing water race from the Arthur River was widened and extended to enable a new processing site to be established at the foot of the self-acting incline further up Tinstone Creek (Fig. 6). A 45kW turbine was ordered in February 1901 and a pit for the turbine house was excavated during March and April.<sup>55</sup> The 10 HB and processing plant commenced operating in September with the turbine working under a 10m head.<sup>56</sup> A requirement for increased water pressures to operate the turbine appears to have led to the construction of another 300m long race from Ritchie Creek (Fig 6). Operations were suspended during 1903 suggesting that unprofitable working followed.<sup>57</sup>

The company was refloated in April 1905 and £8,000 had been raised by March 1908 to enable a steam-powered mill to be constructed further up Tinstone Creek requiring another race to be cut from the head of Ritchie Creek to provide processing water and a storage dam to be constructed.<sup>58</sup> The mine then worked profitably for some 20 years, albeit sporadically at times when the tin price dropped to unacceptable levels. A shutdown occurred at the beginning of 1925 to enable conversion to electric power following an agreement with the Mount Bischoff TM Co. but intermittent working followed.<sup>59</sup> A return to water power occurred between 1936-1940 when the GPS Syndicate used a 4m diameter waterwheel to rework tailings, this being the last recorded waterwheel to operate at the Mount.<sup>60</sup>

### **Mount Bischoff TM Co.: water supply issues 1890 - 1915**

The initial water supply dams and flumes were largely timber structures requiring continual maintenance and regular replacement. Fluming from the Waratah and Falls Creek dams was renewed during 1890 and a cemented stone facing was also added to the Waratah dam, the costs being shared with the Stanhope and Mount Bischoff Extended TM Co's.<sup>61</sup> Shrinkage during the summer months often resulted in all available carpenters being engaged on essential repairs to minimise water losses. This was the case in 1890 when three of the dams were re-caulked and the 'joints battened', the upper five seams in the face of the 'Railway Dam' also requiring attention.<sup>62</sup> Extensive repairs to the timber-faced dams were again undertaken during the 1897 summer. The tramway culvert also required a substantial upgrade by 1895 when a 138m

section of timber fluming was replaced by 0.6m diameter iron piping. A further 100m section was also re-timbered.<sup>63</sup>

Following the completion of the Falls Creek water storage system, the first prolonged water shortage, with the exception of reduced supplies during the summer months, was reported in June 1890, when all of the Falls Creek reservoirs were empty and the ‘small quantity coming from the Fossey and Waratah is hardly worth mentioning’. In response, the Fossey fluming was widened during 1891 to increase flows.<sup>64</sup> The dams were reported to be full during much of the remaining 1890s, the next significant stoppage occurring in 1898.<sup>65</sup> Despite this, one of the Falls Creek dams was replaced by a 10m high masonry structure in November 1894 to increase the overall storage capacity to 2230ML and yet another dam was constructed on the Waratah during 1911 to add a further 910kL. The total cost of the water storage projects up to 1895 amounted to £22,395.<sup>66</sup>

Data on the rate of water consumption is sparse with assistant manager, Hyman Herman, claiming in 1914 that detail measurements had not been undertaken during the Kayser years. A rate of 189kL per hour for mineral dressing and power generation was published in 1895 but by 1914 gauging by Herman revealed that 410kL per hour was used for mineral dressing and a staggering 2.5ML per hour for power generation following the completion of a hydroelectric plant (see below).<sup>67</sup> At that rate of consumption, the stored water would have lasted just 44 days without replenishment. It is therefore not surprising that summer shutdowns continued, as for example in 1911.<sup>68</sup>

The annual cost of maintaining the water supply system is revealed in the minutes of the shareholders meetings. During the period 1886 - 1900, maintenance of the dams and water races typically formed 15–35 percent of the combined costs for both the water supply system and the acquisition of new plant. This increased to 45–55 percent during periods of new dam construction and was a significant cost item on the balance sheet. When compared to the total profits of £1,500,759 accrued by 1895, a maximum estimated cost of waterworks to that date of approximately £50,000, must be considered a sound investment.<sup>69</sup>

### **Mount Bischoff TM Co.: hydro-electric power development 1906-07**

The credit for promoting a hydro-electric scheme was claimed by Millen’s assistant, Hyman Herman, the rationale being that by placing

an electric power station near the Ringtail sheds, utilising the water power under a head of 560ft instead of 100ft [the average fall for the large diameter waterwheels] thereby quadrupl[ed] ... the power hitherto obtained from it.<sup>70</sup>

The construction contract was awarded to Noyes Bros of Melbourne and was underway at the beginning of 1906.<sup>71</sup> The project comprised the construction of a supply race approximately 2km in length from the Waratah River through the southern mining lease to a point below the White Face (Fig. 7). The race was constructed partly of a timber trough along the ground surface and partly of elevated wrought iron fluming to maintain a consistent grade of 1 in 525 (0.11°). The fluming discharged into a 7.6m diameter wrought iron header tank that fed a 412m long pipe column (460mm diameter) extending to the powerhouse. Three pelton wheels were installed, two 150kW units supplied by Escher Wyss & Co of Zurich, Switzerland and a single 335kW unit by J.M. Voith of Heidenheim, Germany to power some 50 electric motors. The maximum efficiency of the Escher Wyss impulse turbines at full gate was stated to be 76 percent compared to 80 percent for the Voith turbine.

The project was commissioned by December 1907 enabling a new 50 HB mill to be developed in stages between 1910-1918 and the waterwheels to be gradually phased out.<sup>72</sup> Another hydro-electric power plant in the north of the State, at Moorina, entered service in March 1909 for the Pioneer TM Co. which utilised three Voith pelton wheels of 325kW output.<sup>73</sup>

#### **Weir's Bischoff Surprise TM Co. 1905 - 1940**

The Weir's Bischoff Surprise TM Co. was formed in 1905 to work alluvial deposits along the northern side of the Waratah River by sluicing. The river was dammed upstream of the workings to feed a water race almost a kilometre in length (Fig. 7) and a 4 HB erected. As the race was of timber construction (that is, above ground), a water-powered sawmill was erected near the confluence of the Arthur and Waratah Rivers that required races to be cut in the basalt bedrock due to the lower elevation.<sup>74</sup> The initial capital raising was soon expended in cutting the races and a further £3,100 was raised to continue.<sup>75</sup> At this point, work was suspended pending the outcome of reviews undertaken by L.B. Mitchell, manager of the Arba tin mine, and a British consultant, Hartwell Condor. Condor endorsed Mitchell's recommendation that a race should be constructed from Lynch's Creek so that pumps to be powered by pelton wheels could be



to Anthony Roberts employing 3-5 men.<sup>79</sup> In 1912 a larger water-powered battery was erected enabling production during the following decade to average 10.5 tonnes tin oxide.<sup>80</sup>

The lease was acquired by the Mount Bischoff TM Co. in 1926 after exploration proved some 765,000 cubic metres alluvial tin grading 0.7kg per cubic metre. A race was cut to utilise the discharge water from the company's powerhouse, approximately 4,800 metres in length, producing a 85m pressure head at the sluicing nozzles. This became the last significant undertaking on the Mount.<sup>81</sup> Mining proceeded through the 1930's but stoppages were noted by the Mines Department particularly during the summer months due to water shortages.<sup>82</sup>

### **Conclusions**

During the initial mine development phase at Mount Bischoff, the adoption of water power was the only practical option to overcome the limitations associated with transport to the remote site and the lack of skilled labour, so as to achieve the economies required until essential revenue could be generated. The site topography, high annual rainfall and multiple water courses surrounding the Mount were all favourable factors for adopting water power. Water supply before 1885 was provided by a network of races having a combined length of about 15 kilometres, which compares favourably with later tin mining developments. Further developments increased this network to some 36 kilometres to enable the hydro-electric power scheme to proceed and to service the more isolated mine leases (see Appendix 1).

Ferd Kayser continued a policy introduced by his predecessor William Crosby, his rationale for proceeding with water power being based on waterwheel technology rather than steam power. This is best summarised in his own words:

At Waratah, as well as at the mine site, the same care has been taken to make the best use of the water, and full advantage has been taken of the natural facilities offered at the machine site. For this purpose the sheds, with the waterwheels, have been so placed that the water from the top one is available for the next one on the floor below, and so on. In all seven wheels work almost with the same body of water, and produce in round figures about 200 h.p., thus securing the greatest amount of motive power with the least possible waste ... I am pleased to say, that I have stuck to the primitive waterwheel, as it is so easily managed by unskilled labour. The result is more satisfactory than if I had selected either the turbine or the Pelton wheel'.<sup>83</sup>

As the introduction of water turbines for industrial applications in Tasmania only gained momentum after 1880, Kayser's attempt to install a water turbine in 1878 was probably premature given the lack of available expertise and resources to ensure a successful outcome. The first documented application of a reaction turbine in the north of the state was at Launceston Council's Cataract quarry to power a rock crusher that commenced in August 1879.<sup>84</sup> Turbines were introduced to New Zealand (with a similar topography) by the mining industry during the 1870s but were used only sparingly in Tasmania from the early 1880s. The pelton wheel, a development of the vertical waterwheel, was promoted in 1885 by Gustav Thureau, in his role as the Tasmanian inspector of mines, and was widely adopted by the mining industry after 1890.<sup>85</sup> Kayser rather belatedly had a small pelton wheel installed at the Ringtail plant in 1897 to provide electric lighting, this coming at the end of his involvement in the day-to-day mine management.<sup>86</sup> Further advances in water power utilisation were not pursued until the hydro-electric development of 1906-1907 that was instigated by Kayser's replacement, John D. Millen and his assistant Hyman Herman.<sup>87</sup>

The hydro-electric power plants of the Mount Bischoff and Pioneer TM Co's pioneered the introduction of electrical power to the mining industry in Tasmania whereby high voltage (alternating current) capacity was used to transmit power over a significant distance to the processing plant. Launceston City Council introduced hydro-electric power to Tasmania when the Duck Reach power station was commissioned on 10<sup>th</sup> December 1895 using both dc and ac equipment for lighting and power supply.<sup>88</sup> All previous applications had utilised turbines or pelton wheels in conjunction with dynamos to supply direct current over short distances, generally for electric lighting, that is, the power generating equipment and processing plant were situated at the same location. Mining operations to follow Mount Bischoff's lead within the next ten years included the Pioneer TM Co. at Moorina in March 1909, the Boulder TM Co. at North Dundas in 1912, the Mount Lyell Mining & Railway Co. at Lake Margaret in 1914, and the Magnet Silver Mine Co. to the west of Mount Bischoff in 1917. It was to take another 20 years or so before power generated by the state run Hydro-Electric Commission became available to remote mine sites in the north of the state.

#### **Acknowledgements**

The assistance of AMHA member Greg Dickens with drawing searches and the supply of plan copies by Mineral Resources Tasmania is gratefully acknowledged.

### Abbreviations

HB = Head battery with the number of stamps given.

MRT = Mineral Resources Tasmania, Department of Infrastructure, Energy & Resources.

TM Co. = Tin mine company.

### Glossary of Terms

*High breast waterwheel*: the water is delivered to the wheel at the 10 o'clock position, the wheel rotating in the opposite direction to that of the water supply in the head race.

*Overshot waterwheel*: the water is delivered at the 1 o'clock position, the wheel rotating in the same direction as the water supply in the head race. Waterwheels of overshot or pitchback design were generally used in elevated areas where high falls were available enabling large diameter wheels of narrow width to be constructed, thereby minimising water usage.

*Pelton wheel*: a form of impulse turbine most suited to locations where a very high head of water is available to produce a high velocity jet that is directed on to cup-shaped buckets around the rim of the wheel.

*Pitchback waterwheel*: the water is delivered to the wheel at the 11 o'clock position, the wheel rotating in the same direction to that of the water supply in the head race.

*Shroud*: the annular rim of a waterwheel that closes the ends of the buckets.

*Water turbine*: comprises an enclosed impeller that includes scientifically-shaped cups or blades, driven by impulse and reaction of water. A higher efficiency, combined with increased speeds and power, are obtained when compared with a waterwheel.

*Wheel arms*: radial members of a waterwheel, acting in compression that provide support to the shroud, commonly fixed to an iron hub or centre.

*Wheel buckets*: partitions around the rim of a waterwheel in which the water is contained, in order to use its weight to turn the wheel.

*Wheel shaft*: the wooden or iron 'axle' on which a waterwheel is mounted.

---

### Endnotes

<sup>1</sup> Margaret Mason-Cox, *Lifeblood of a Colony: a History of Irrigation in Tasmania*, Rivers & Water Supply Commission, Hobart, 1994; Roger Lupton, *Lifeblood: Tasmania's Hydro Power*, Focus Publishing, 2000.

<sup>2</sup> H.W.F. Kayser, 'Mount Bischoff', *Proceedings of the Australasian Association for the Advancement of Science* [hereafter *PAAAS*], no. IV, 1892, pp. 342-47; D.I. Groves, E.L. Martin, H. Murchie, & H.K. Wellington, 'A Century of Tin Mining at Mount Bischoff 1871 - 1971', *Mineral Resources Tasmania*, Geological Survey Bulletin no. 55, [hereafter *MRT GSB* no.55], 1972; Kerry Pink, *The West Coast Story*, West Coast Pioneers Memorial Museum, 1982, pp. 46-55; Nic Haygarth, 'King of the Waratah – Ferd Kayser and the Mount Bischoff Tin Mine', in *Papers and Proceedings Tasmanian Historical Research Association*, vol. 48, no. 3, September 2001, pp. 205-19.

<sup>3</sup> Kayser, 'Mount Bischoff', 1892, p. 346.

<sup>4</sup> *Hobart Mercury*, 17 January 1874, 16 July 1874.

<sup>5</sup> *Ibid.*, 16 July 1875.

<sup>6</sup> *Ibid.*, 11 January 1875, 16 July 1875; *Illustrated Tasmanian News*, March 1875; *MRT, GSB*, no. 55, p. 32.

<sup>7</sup> *Illustrated Tasmanian News*, March 1875.

<sup>8</sup> *Cornwall Chronicle*, 5 July 1875.

<sup>9</sup> See Nic Haygarth, *Baron Bischoff: Philosopher Smith and the Birth of Tasmanian Mining*, Hong Kong, 2004, pp. 91-110, for an account of the conflict between William Crosby & James Smith with Ferd Kayser and Kayser's brief flirtation with steam power.

<sup>10</sup> *Ibid.*, 16 April 1875, 5 July 1875.

<sup>11</sup> *PAAAS*, pp. 345 & 347; *Hobart Mercury*, 29 August 1876.

<sup>12</sup> *Cornwall Chronicle*, 19 March 1877.

- <sup>13</sup> *Illustrated Tasmanian News*, September 1875; *Hobart Mercury*, 13 October 1875, 2 February 1876; *Cornwall Chronicle*, 17 May 1876.
- <sup>14</sup> *Cornwall Chronicle*, 19 March 1877.
- <sup>15</sup> *Ibid.*, 14 January 1878, 18 February 1878.
- <sup>16</sup> *Ibid.*, 5 December 1878, 8 January 1879, 23 January 1879.
- <sup>17</sup> Haygarth, 'King of the Waratah ...', p. 215.
- <sup>18</sup> *MRT, GSB*, no. 55, p. 67.
- <sup>19</sup> T. S. Reynolds, *Stronger than a Hundred Men - A History of the Vertical Water Wheel*, John Hopkins University Press, 1988.
- <sup>20</sup> *Mount Bischoff TM Co.*, 'Director's Report', State Library Tasmania, 30 June 1880; *PAAAS*, p. 348.
- <sup>21</sup> *Cornwall Chronicle*, 18 February 1878.
- <sup>22</sup> *Ibid.*, 20 February 1879.
- <sup>23</sup> *PAAAS*, pp. 350-51.
- <sup>24</sup> *Hobart Mercury*, 19 January 1878; *Cornwall Chronicle*, 1 April 1878.
- <sup>25</sup> *Ibid.*, 11 March 1879, 2 September 1879; *Cornwall Chronicle*, 1 January 1880.
- <sup>26</sup> *Cornwall Chronicle*, 1 January 1880; *Tasmanian Mail*, 1 July 1882.
- <sup>27</sup> *Ibid.*, 1 April 1879.
- <sup>28</sup> *PAAAS*, pp. 348-349.
- <sup>29</sup> *Cornwall Chronicle*, 1 January 1880; *Mount Bischoff TM Co.*, 'Director's Report', State Library Tasmania, 30 June 1880.
- <sup>30</sup> *Hobart Mercury*, 1 August 1882; 'Hyman Herman: Australian Tin Lodes and Tin Mills', *Proceedings Australasian Institute Mining Engineers*, [hereafter *PAIME*], no. 14, 1914, p. 354.
- <sup>31</sup> *Hobart Mercury*, 1 February 1883.
- <sup>32</sup> *Daily Telegraph*, 1 August 1884.
- <sup>33</sup> *Ibid.*
- <sup>34</sup> *PAIME*, pp. 354-55 & 360-61.
- <sup>35</sup> Specification in the Salisbury Collection, Queen Victoria Museum & Art Gallery, Launceston.
- <sup>36</sup> *Tasmanian Mail*, 5 August 1882; *Hobart Mercury*, 1 February 1883; *Daily Telegraph*, 1 August 1884.
- <sup>37</sup> *MRT, GSB*, no. 55 p. 70; *Tasmanian Mail*, 15 March 1884.
- <sup>38</sup> *Daily Telegraph*, 30 January 1885; Haygarth, 'King of the Waratah ...', p. 210.
- <sup>39</sup> *Tasmanian Mail*, 28 November 1885, 6 February 1886.
- <sup>40</sup> *Ibid.*, 7 August 1886, 1 February 1887.
- <sup>41</sup> *Town & Country Journal*, 1 July 1893; *PAIME* p. 359; *MRT, GSB*, no. 55, p. 83.
- <sup>42</sup> The waterwheel is also visible in a photographic plate reproduced in Haygarth, *Baron Bischoff: Philosopher Smith and the Birth of Tasmanian Mining*, p. 108.
- <sup>43</sup> *Tasmanian Mail*, 1 February 1887.
- <sup>44</sup> *Hobart Mercury*, 30 August 1881.
- <sup>45</sup> *Ibid.*, 30 August 1881, 20 December 1881; *Tasmanian Mail*, 25 August 1883.
- <sup>46</sup> *Ibid.*, 3 August 1883, 1 September 1884.
- <sup>47</sup> *Daily Telegraph*, 30 January 1885; *Tasmanian Mail*, 7 February 1885, 9 January 1886, 6 February 1886; H.W.F. Kayser: 'Mount Bischoff Tin Mine, Tasmania, *Minutes & Proceedings Institution Civil Engineers* [hereafter *MPICE*], vol. 123, no. 1, 1895-96, p. 386; *PAAAS*, p. 348.
- <sup>48</sup> *Daily Telegraph*, 30 January 1885; *Tasmanian Mail*, 8 August 1885.
- <sup>49</sup> *Tasmanian Mail*, 6 February 1886, 7 August 1886; *Daily Telegraph*, 1 February 1887; *Hobart Mercury*, 1 February 1888.
- <sup>50</sup> *Ibid.*, 9 January 1886, 29 May 1886, 1 June 1886; *Hobart Mercury*, 15 February 1886.
- <sup>51</sup> *Hobart Mercury*, 29 March 1887; *Tasmanian Mail*, 1 June 1887.
- <sup>52</sup> *Daily Telegraph*, 4 May 1889, 1 August 1889, 1 August 1890, 2 February 1891; *Hobart Mercury*, 23 April 1890.
- <sup>53</sup> *Ibid.*, 3 August 1891, 1 August 1895; *Hobart Mercury*, 27 August 1890.

- 
- <sup>54</sup> *PAIME*, p. 355; A photographic plate reproduced in Haygarth: *Baron Bischoff: Philosopher Smith and the Birth of Tasmanian Mining*, p. 108, 2004, is believed to show the machinery shed and the large diameter overshot waterwheel of the North Valley plant. Although the waterwheel was described as being of iron construction, wooden arms were retained.
- <sup>55</sup> *Hobart Mercury*, 3 August 1900, 8 February 1901, 15 March 1901, 13 May 1901.
- <sup>56</sup> *Ibid.*, 5 September 1901; *PAIME*, p. 368.
- <sup>57</sup> Journals of the House of Representatives, Tasmania [hereafter *TPP*], Report Secretary for Mines, August 1903, vol. 49 no.17, p. 39.
- <sup>58</sup> *Hobart Mercury*, 6 April 1905, 10 March 1908; *TPP*, vol. 65, no. 37 July 1911, p. 12; *PAIME*, p. 366-67.
- <sup>59</sup> *TPP*, vol. 95, no. 1, June 1926, p. 10.
- <sup>60</sup> *TPP*, vol. 117, no. 5, June 1937, p. 29.
- <sup>61</sup> *Daily Telegraph*, 3 February 1890.
- <sup>62</sup> *Tasmanian Mail*, 7 June 1890; *Daily Telegraph*, 1 August 1890.
- <sup>63</sup> *Daily Telegraph*, 1 August 1895, 1 February 1897.
- <sup>64</sup> *Tasmanian Mail*, 7 June 1890; *Daily Telegraph*, 2 February 1891.
- <sup>65</sup> *Daily Telegraph*, 30 July 1898.
- <sup>66</sup> *Hobart Mercury*, 15 November 1894; *PICE*, p. 386; H.W.F. Kayser, 'Tin-Mining in Tasmania', *Transactions of the Federated Institution of Mining Engineers (Great Britain)*, 1896-97, pp. 570-82; *TPP*, vol. 65, no. 37, July 1911, p. 11.
- <sup>67</sup> *MPICE*, p. 386; *PAIME*, p. 361.
- <sup>68</sup> *TPP*, vol. 65, no.37, July 1911, p. 11.
- <sup>69</sup> *MPICE*, p. 387.
- <sup>70</sup> *PAIME*, p. 361.
- <sup>71</sup> *MRT, GSB*, no. 55, p. 47.
- <sup>72</sup> *The Mining Journal (Great Britain)*, 3 September 1910, p.1072; *MRT, GSB*, no. 55, p. 48.
- <sup>73</sup> Geoff Wilson (ed.), *As the River Flows – A history of Ringarooma Municipality*, The Ringarooma Council, 1988, p. 46.
- <sup>74</sup> *Hobart Mercury*, 26 July 1905, 25 January 1906, 30 March 1906.
- <sup>75</sup> *Ibid.*, 30 November 1906, 14 May 1907.
- <sup>76</sup> *Ibid.*, 19 January 1907, 11 April 1907, 1 May 1907.
- <sup>77</sup> *Ibid.*, 24 June 1907, 8 July 1907, 16 July 1907.
- <sup>78</sup> *Ibid.*, 19 August 1907. It is clear from the progress reports during the period of water race construction that the term 'levelled' was used for 'completion' of construction.
- <sup>79</sup> *Ibid.*, 23 September 1908, 18 March 1909.
- <sup>80</sup> *TPP*, vol. 67, no. 20, June 1912, p. 19, through vol. 87, no.5, April 1922, p. 11.
- <sup>81</sup> W.H. Porte, 'Tin Mining at Mount Bischoff', *Chemical Engineering and Mining Review*, 10 June 1938, p. 351.
- <sup>82</sup> *TPP*, vol. 113, no. 27, June 1935, p. 25 & vol. 117, no. 5, June 1937, p. 29.
- <sup>83</sup> *PAAAS*, p. 351.
- <sup>84</sup> The history of Launceston's Cataract Gorge quarry is outlined by the author in 'The Cataract Hill Quarry', in P.A.C. Richards & M. Johnson (eds), *Health, Wealth and Tribulation - Launceston's Cataract Gorge*, Myola House of Publishing, South Launceston, 2003, Ch. 8.
- <sup>85</sup> W.F. Durland, 'The Pelton Water Wheel - Developments by Pelton and others prior to 1880', *Mechanical Engineering*, vol. 61, 1939, pp. 447-54; *TPP*, vol. 6, no. 59, 1885, pp. 8-11.
- <sup>86</sup> *MRT, GSB*, no. 55, p. 70; Haygarth, 'King of the Waratah...', p. 211.
- <sup>87</sup> *APAIME*, p. 361.
- <sup>88</sup> Lupton, *Lifblood: Tasmania's Hydro Power*.

## APPENDIX, 1

### *Principle Water Supply Races*

<b>Operator &amp; Race Location</b>	<b>Water Source</b>	<b>Construction Date</b>	<b>Length (metres)</b>	<b>Comments</b>
MB: Wararah River	Waratah R	By 1/1876	470 (23)	Ran from the first dam constructed to the MB and ST leases, extended to the NBV lease in 1882.
MB: Falls Creek	Falls Ck	1/1880 - 12/1880	2415 (120)	Ran around the cliff top to the north of the township to the MB processing site.
WB: West Bischoff	Arthur R	3/1881 - 3/1882	2620 (130)	Plant at Arthur R/Tinstone Ck confluence, race extended 500m by MBE in 1901.
MB: Tramway Culvert	Subsurface + Falls Ck	8/1884 - 4/1888	1810 (90)	Alignment from the Falls Ck dam site to the Waratah Bridge.
MB: Fossey Scheme	Fossey R	3/1885 - 1/1886	7070 (350)	Discharged into Falls Ck Dam No: 5
MBE: Tinstone Ck	Ritchie Ck	1901	300 (15)	Provided water supply for a turbine.
WBS: North Valley	Waratah R	3/1905 - 3/1906	955 (48)	Along northern side North Valley.
MB: Power Station	Waratah R	1906 - 1907	2010 (100)	Along southern side North Valley, 412m pipe column to turbines.
WBS: Deep Gully Creek	Lynch's Ck	1907	9060 (450)	Along southwestern side Deep Gully Ck and east side Arthur/Waratah Rivers.
MBE: Tinstone Creek	Ritchie Ck	1911	4530 (225)	Tapped headwaters of Ritchie Ck.
MB: North Valley	Waratah R	1927 - 28	4830 (240)	Ran from MB power station along northern side of North Valley, 300m pipe column.

Notes:

*Column 1.*

MB = Mt Bischoff TM Co.

MBE = Mt Bischoff Extended TM Co.

NBV = North Bischoff Valley TM Co.

ST + Stanhope TM Co., WB = West Bischoff TM Co.

WBS = Weir's Bischoff Surprise TM Co.

*Column 4*

Numbers in brackets refer to measurement in chains.